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WEAVING AND DESIGNING.

A PRACTICAL TREATISE

ON

WEAVING AND DESIGNING

OF

TEXTILE FABRICS,

WITH CHAPTERS ON THE PRINCIPLES OF CONSTRUCTION OF THE LOOM, CALCULATIONS, AND COLOUR.

THIRD EDITION.

BY

THOS. R. ASHENHURST,

Head Master of the Textile Department Bradford Technical College, and formerly Instructor at Stroud, in connection with Bristol University College.

WITH ABOUT THREE HUNDRED AND SIXTY ILLUSTRATIONS.

HUDDERSFIELD:
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PREFACE TO THIRD EDITION.

Since the two previous editions of this work were issued, it has been my privilege to continue the work of teaching the subjects dealt with in this treatise, and also to issue several other works bearing more or less upon many of the matters treated upon in this one. During this time, of necessity, many questions have been brought under my notice in reference to this work, and many weaknesses have been pointed out in it, and in this edition I have endeavoured to deal with those questions and to strengthen the weak points, and to endeavour to make this work, along with the others just mentioned, cover the ground of Textile Manufacturing, so far as Weaving and Designing are concerned, as completely as possible, and to render all the assistance in my power to students engaged in this work.

Owing to the numerous alterations, considerable delay has been occasioned in the issue of the work, the duties of my position having prevented me giving the necessary time to it to complete it at an earlier date. I can only hope the delay will be compensated for by the completeness of the work.

THOS. R. ASHENHURST.

BRADFORD,
September, 1885.

PREFACE TO SECOND EDITION.

No better proof of the need of a treatise on weaving could be afforded than the early demand for a Second Edition of this book; nor could a better proof be found, that the youths and workmen engaged in textile manufactures are fully alive to the necessity of a better knowledge of their business, than the general demand for the work in a cheaper form, so as to come easily within the reach of the working classes.

The subject of "Weaving and Designing of Textile Fabrics" is one which covers a wide field, and the few works which do exist upon the subject can, at the most, only be considered as elementary works; but the eagerness with which even these are sought up, by those most interested, induces the hope that the new literature of an old industry may, ere long, develope to such an extent that it may be worthy of the fame of that industry.

In preparing this Edition for the press, I have been enabled to revise it, and to correct many of the errors which appeared in the First Edition, and to make such alterations and additions as appeared necessary. That the work may prove an assistance to the student and workman, and be a stepping-stone for further efforts, is the earnest hope of

THOS. R. ASHENHURST.

BRADFORD,
January, 1881.

PREFACE TO FIRST EDITION.

In writing and placing this work before the public, the object which I have had in view has been to assist in furthering the efforts which are now being made to promote the advancement of technical education in connection with the textile trades in this country.

For a considerable time it has been apparent that our Continental neighbours have been making rapid progress in the art of manufacture, and it only required a little inquiry to explain the reason of that rapid progress. Schools of instruction have been in existence, and have been spreading over the country, for the purpose of training those who were intending to devote their lives to the production of textile fabrics, and in those schools everything has been taught which would have any bearing upon the branch of manufacture to which they gave their attention. While this has been going on abroad, not the slightest attention has been paid to the subject at home until the matter has been forced upon those engaged in the trade by the discovery that foreign competition was affecting very materially the markets in which they were wont to sell their goods, and that the nature of this competition clearly proved that the competitors were thoroughly masters of their business. This discovery having been made, inquiries began to be instituted as to the cause, and the best means of meeting it, the result being the establishment of schools of instruction in the textile trades in various centres of industry. In the promotion and establishment of these schools the Worshipful Clothworkers' Company, of London, have taken a most

laudable part by granting liberal endowments to the principal ones, and taking a lively interest in their progress and welfare, and in other ways fostering and supporting technical education.

The writer of the present work having been brought into connection with those schools under the auspices of the Worshipful Company of Clothworkers, by his appointment in the year 1877 to the lectureship on the technology of textile manufactures, at Bristol University College of which they were the promoters, and again by the liberal endowment they have been pleased to grant to the school of which he has now the honour of being chief instructor, he has great pleasure in dedicating to the Master and Wardens of the Worshipful Company this the result of his labours, in the hope that it may be of some little value in assisting the great work they have in view, by placing before the students, in as concise a form as possible, the information which he has been able to acquire upon the subject with which he has attempted to deal.

If the perusal of this volume should assist the student in any degree in mastering the details of his craft, the author will feel that his labours have not been all in vain and that he has done something towards maintaining the supremacy of our manufactures, and thereby maintaining that commercial position which has been the great source of wealth, as well as the pride and glory of the English people.

The rise and progress of the textile manufactures of this country have, within the last century, been something marvellous, and the products of the loom have in no small degree contributed to the wealth of the nation. Yet it is a remarkable fact that this art, which has done so much for the wealth of this country, and which plays a greater part in civilisation than perhaps any other, possesses fewer works or treaties than any other of the arts or manufactures of this country.

The present work does not profess to deal exhaustively with the subject; the aim has been to reduce the whole art of weaving and designing of textile fabrics to simple principles, and to lay them before the reader in as brief and concise a form as possible, with just sufficient illustrations to make the matter clear and intelligible, and free it from that ambiguity which frequently characterises works of this description.

It is quite possible that the attempts here made at classification may not coincide with the views or meet with the approval or assent of many engaged in the trades. If such be the case, I must ask those who differ from me to believe that the object I have in view is to simplify, and by that means promote a more extensive knowledge than has hitherto existed of the principles of "Weaving and Designing of Textile Fabrics."

T. R. A.

BRADFORD, 1879.

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WEAVING AND DESIGNING OF TEXTILE FABRICS.

INTRODUCTION.

Man in his natural state has few wants to provide for, food and clothing being the principal, and to provide the latter in a suitable form is a subject which occupies a considerable portion of time in civilised life. One writer observes that, "though we find finery and external adornments common to every people, yet comfortable clothing is almost exclusively confined to the inhabitants of those portions of the globe which are far advanced in civilisation." Man's first article of clothing seems to have been fig leaves, and immediately afterwards the skins of beasts. If we refer to Holy Scripture we shall find that the skins of animals were the coverings of our first parents. "Unto Adam also and to his wife did the Lord God make coats of skin, and clothed them."—*Gen.* iii. 21. The immediate descendants of Adam also used coats of skin, and shortly afterwards the *Simla*, an upper garment consisting of a piece of cloth, according to Professor Hurwitz about six yards long, and two or three wide, and greatly resembling a blanket in shape, became their chief article of dress. Other garments made of wool, and other material also, were in course of time fabricated. In *Leviticus* xiii. 47, 48, we read "The garment also that the plague of leprosy is in, whether it be a woollen garment or a linen garment, whether it be in the warp or woof," thus showing, by the reference

to "warp and woof," that the art of weaving was practised in those days. Other arts also sprung into existence, and were prosecuted with considerable success, but spinning and weaving were undoubtedly among the earliest arts known to man, and at the present day they are among the arts which form the main distinction between savage and civilised life. Manufactures of goats' hair were at an early period used in making tents, similar to those the Arabs of the present day are in the habit of constructing. This manufacture is supposed by some to have been spun and woven according to the worsted process, resembling to some small extent the manufacture of mohair at the present day, as contra-distinguished from the making of woollen or felted cloths.

The art of weaving is of great antiquity among the Chinese, Hindoos, and Egyptians, and has been practised by them for thousands of years. Pliny says the Egyptians were the inventors of weaving—"That the Egyptians put a shuttle in the hands of their Goddess Isis, to signify that she was the inventress of the art of weaving."—*Strutt on Dress.* However this may be, weaving was undoubtedly practised by them from a very remote period, and this is one of the arts of which, if Egypt was not "the mother," she was certainly "the nurse" and both with the Egyptians, the Chinese, and the Hindoos, spinning and weaving were carried to great proficiency, and the productions of the distaff and the primitive loom would compare very favourably, for fineness and delicacy—if they would not indeed surpass—the productions of the modern manufacturer. It would be very difficult indeed to say which country could claim the palm of invention, because it seems to have been practised very largely by all from a very remote period; and it would be equally difficult to say what material was first used, because different materials were in use by different people about the same time. It is said of the

Chinese that they can trace back documentarily the use of silk fabrics as far as the twenty-sixth century before our era. With the Egyptians linen has long been in use, and at a very early period of their history they spun and wove it so extremely fine that their fabrics have been the wonder and admiration of succeeding ages. Wool was the material used in some other countries, notably in Asia ; and the Hindoos worked in cotton, as well as wool and goats' hair.

Not only in the civilised, but in the less civilised portions of the New World, and even among savages, the practice of weaving is to be found. Clavigero, in his history of Mexico, shows that on the conquest of that country, weaving was found to be practised by the natives; and Park, in his Travels, says it is practised by the savages of Central Africa.

There are four kinds of material chiefly used in the fabrication of cloths for garments, viz, Wool, Flax, Cotton, and Silk, without taking into account Jute and other fibres, which are also used occasionally, or which are used in the manufacture of fabrics for other than clothing purposes. Of these it is very probable wool was first used. If we refer to *Gen.* iv. 2, xxxvi. 7, and xxxvii. 13, and to *Job* xlii. 12, we find that the keeping of sheep must have been a profitable employment in very early times, and at later periods in the history of the world this occupation has lost none of its value or importance. That the Hebrews and their neighbours deemed it honourable, even for royalty, there is Bible evidence abundant to prove. If we refer to 2 *Kings* iii. 4, we find that "Mesha, King of Moab, was a sheep master, and rendered unto the King of Israel an hundred thousand lambs, and an hundred thousand rams, *with the wool.*" Two eminent authorities, Whitaker in his History of Manchester, and Strutt on Dress, both assert that the first articles of dress were made from wool ; and this may be very readily inferred, because those who were

in the habit of wearing the skins of wool-bearing animals could not fail to discover the peculiar properties of wool; properties which make it an easy matter, either to make threads from it, or form it into a solid substance without the preliminary process of spinning, or even of weaving.

The manufacture of worsted is supposed by some to have preceded that of woollen, and in support of this the writer of the article in Rees' Cyclopædia says the "long-stapled wool suited to the comb seems more spontaneously the produce of uncultivated sheep than short wool, which is to be manufactured by carding."

Some writers suppose the *Argali* species to be the original sheep. Prof. Archer says, "The fact that the sheep has been so long domesticated has caused it to be a matter of uncertainty whether it has been derived from any of the existing animals of the genus *Ovis*. Many have entertained the opinion that it is the same animal as the Argali, *Ovis Ammon*, Linn., a native of the mountains of Central Asia; and a great weight of evidence in favour of that supposition is obtained from the circumstance, that all the tribes of people who have from time immemorial dwelt on the plains surrounding those mountains have always been pastoral in their habits and occupations. Still, however, there is no positive proof that our sheep was derived either from the Argali or any other known wild species, and the probability has been much lessened by the recent discoveries of the remains of sheep, mingled with stone weapons of a people who existed under such different conditions of the earth's surface, that we may assume with as much probability that they were the progenitors of the Asiatics, as that the latter were their ancestors." And Dr. Carpenter, in his Zoology, says the Argali is not the original sheep.

In addition to woollen fabrics other material appears to have been used by the ancients, viz., linen and silk (the

manufacture of the latter having been brought to great perfection by the Chinese in very early times), and not only were they used separately, but they were in the habit of mixing them in their goods. "Neither shall a garment mingled of linen and woollen come upon thee."—*Lev.* xix. 19. The practice of mixing seems to have been carried on at a later period also. The *subsericum** of the Romans was a mixture of woollen and silk, viz., woollen warp and silk weft. It has been supposed by some that the "garment mingled of linen and woollen," forbidden by Moses, was a cloth which the Egyptians were accustomed to manufacture, inasmuch as he prohibited almost every custom prevalent in Egypt.

The Hebrews appear to have obtained a knowledge of spinning and weaving during their bondage in Egypt, and to have exercised their knowledge while journeying in the desert—"And all the women that were wise-hearted did spin with their hands, and brought that which they had spun both of *blue*, and of *purple*, and of *scarlet*, and of fine linen; and all the women whose heart stirred them up in wisdom spun *goats' hair*."—*Exodus* xxxv. 25.

This practice was no doubt followed up by them after they ceased their wanderings. In the *Proverbs of Solomon* xxxi. 13, some of the qualities of a virtuous woman are said to be that "She Seeketh wool and flax, and worketh willingly with her hands." But the Hebrews never seem to have attained great excellence in their manufactures; but to have confined themselves to coarse fabrics, which were spun under the domestic roof.

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* Silk is described by the Ancients as coming from *Serica* or *Sereinda*. *Seres* is the designation given by the Greeks and Romans to the people who inhabited those remote regions, and Sereinda is apparently a compound of *Seres* and *Indi*— the latter a general term applied by the ancients to all distant nations. It is generally admitted that the *Seres* of the ancients are the Chineses of the moderns. *Se* is the name for Silk in the Chinese language. —*Treatise on the Silk Manufacture.* London; Longman & Co. 1831.

In 1 *Kings* x. 28, we find Solomon receiving "linen yarn" from Egypt. Linen would appear to have been the chief product of the Egyptians, for we find it very frequently mentioned, and in the manufacture of linen they undoubtedly excelled. We find *Ezekiel* xxvii. 7 speaking of "Fine linen and broidered work from Egypt." And as they cultivated the manufacture of linen to perfection, they seem to have almost entirely neglected that of wool; indeed, it seems to have been a part of their religion to eschew the use of sheep's wool, and to abominate the pastoral life. Possibly this arose from political causes, such as repeated invasions by their pastoral neighbours, and the long and tyrannical dynasties of their occasional conquerors—the shepherd kings.

Whatever may have been the cause, the Egyptians disliked sheep's wool, and cultivated vegetable fibres which, with their fine and equable climate, probably formed the better material for clothing. The perfection to which they brought the manufacture of their favourite material is well seen in the marvellous fabrics which are found in such abundance in the receptacles of their dead.

Dyeing is mentioned as early as the time of Jacob—"Now Israel loved Joseph more than all his children, because he was the son of his old age, and he made him a coat of many colours."—*Gen.* xxxvii. 3. Woollen fabrics appear to have been first named from the peculiar colours in which they were dyed. For instance, in the following verse we read, "Moreover thou shalt make the tabernacle with ten curtains, of fine twilled linen, and *purple*, and *Scarlet*."—*Exodus* xxvi. 1. It is pretty well established that the latter portion alludes entirely to woollen fabrics.

We read in *Numbers* iv. 6, 7, 8, of "cloth wholly of blue," a "cloth of blue," and a "cloth of scarlet," and frequently throughout the old Testament we find woollen cloth spoken of in this manner.

Gorgeous colours are still preferred in the East, where the art of dyeing originally made great progress, and the excellence of which is, even at this day, attested by the brilliancy of colour which distinguishes the rich carpets of Persia and Turkey, and gives them such a ready sale in the European markets.

A dress of rich and various colours was in the time of Samuel the distinguishing attire of a king's daughter—"And she had a garment of divers colours upon her, for with such robes were the king's daughters, that were virgins, apparelled." The dyeing of these variegated colours must have been a costly art, as is shown by the fact of this description of dress being worn only in the families of princes and nobles. The Phœnicians attained great eminence in the art of dyeing; the Tyrian purple, believed to be obtained from the animal of a sea-shell, *Murex truncatula*, is known to every classical scholar by the numerous allusions to its great repute amongst the ancients.

Tyre was a city famous for its textile manufacture. Ezekiel in his description shows plainly that the woollen manufacture had made considerable progress there; and that its fabrics were the produce of several large and important districts, the names of which are given, and also the peculiar description of materials in the fabrication of which they each excelled.

The isles of Elisha brought to the emporium of the east for merchandise, "blue and purple" Syria, "purple and embroidered work" and Dedan, "precious clothes for chariots." Damascus is mentioned as supplying the merchants of Tyre with "white wool," which was exceedingly rare, and principally confined in its growth to the district immediately surrounding the city from whence it was conveyed. Speaking of the merchants of Sheba, Asshur, Chilmad, and others, the prophet adds, "They were the

merchants in all sortsof things, in blue cloth and broidered work."

No more convincing proof exists of the extent of the manufactures from wool, at this remote period, than this truly eloquent and vivid description of Tyre by Ezekiel in which "white wool" and "blue cloth" are so expressly alluded to.

The Babylonians became famous for their manufacture of stuffs from the finest description of wool. Herodotus says, "They wear a gown of linen flowing down to the feet, over this an upper garment made from wool, and a white tunic covering the whole." "As the climate of Babylonia is excessively hot, we may conclude that these garments made from wool were similar to some of our fabrics, light and of delicate texture."* Babylon, the most celebrated mart of ancient commerce, was distinguished for the extent of its trade, and especially for the productions of its looms. Large and numerous weaving establishments were not confined to the city, but were scattered through the towns of the province, and their woven stuffs conveyed to all the countries of the east. The skill, industry, and enterprise of its inhabitants were unrivalled; the productions of their looms of so fine a texture as to be held in great estimation in all the marts of the world. If we may place implicit belief in the accounts which have descended to us respecting the fineness of their cloths, they were even superior to the extraordinary fabrics of modern times.

The Greek colonies in Asia Minor gave an impetus to the manufacture of wool for ornamental as well as useful purposes, and the Ionian colony of Miletus was especially celebrated for its fine wool and its beautiful carpets; and both of these are supposed to have been first obtained from

* "James' History of the Worsted Trade."

the Coraxi, a native race who are supposed to be represented by the Circassians. The Milesians became so famous for their fine wool that the Coraxi fell into the second rank. Still the latter retained pre-eminence for their shawls, which were so celebrated that they are memtioned in a poem by Hipponax, of Ephesus, 540, B.C. It is, however, considered probable by some that the shawls of the ancestors of the Circassians, and probably too the carpets of Miletus, were made from goats' wool, which is the material of the Cashmerian shawl of modern times. This is the more likely, for some of the ancient authors likened the Melesian fleeces to the wool of the camel, and every one who is familiar with the feeling of camel hair or wool, knows how strongly it resembles in that respect the wool of the Cashmere goat, of which the most beautiful shawls are made.

Like the Phœnicians, the Milesians also became very famous for their dyes; thus we find in Sotheby's translation of the third Georgiac of Virgil, the following lines :-

> Let rich Miletus vaunt her fleecy pride,
> And weigh with gold her robes in purple dyed.

It is almost certain, from the facts already adduced, that the textile manufactures received a great impetus in Egypt—the cradle of nearly all known arts—from whence in course of time, as a necessary consequence of war, revolution, and increase of population in other parts of the globe they became extended throughout nearly the whole of Asia, and from thence to Italy, Portugal, and Gaul, keeping steady pace with the march of civilisation.

The woollen manufacture in Europe appears to have been first established in Italy, from whence most other countries of Europe were accustomed to obtain their best description of clothing. Among the Italian cities engaged in the manufacture or merchandise of woollen and worsted, Venice stands pre-eminent. In the earliest periods she

traded with Constantinople for the best of these articles. On the sack of that city by the French and Venetians, in the beginning of the thirteenth century, the latter carried away its arts and manufactures, and established them in Venice. The historian of that Republic states that it was from Constantinople the Venetians took the first model for their manufactures.

The textile fabrics of both the Greeks and Romans were almost entirely of woollen. Robertson, in his Dissertation on Ancient India, says, "The dress both of the Greeks and Romans was almost entirely woollen, which, by their frequent use of the warm bath, was rendered abundantly comfortable. Their consumption of linen and cotton cloths was much inferior to that of modern times, when these are worn by persons in every rank of life."

The Florentines figure as having been extensively engaged in this branch of manufacture, more so than other portions of Europe, whom they, in consequence, supplied with woollen articles of the finest quality and softest texture.

No sooner was this art known in the Netherlands than it was prosecuted with such unparalleled vigour and success as completely to throw into the shade even Italy, and the towns upon the coast of the Baltic who were engaged in it.

Throughout the early history of Europe the inhabitants of the Netherlands, especially those of Flanders, Brabant, and Hainault, took the lead among manufacturing nations. At a very early period, certainly as early as the tenth century, the woollen and worsted manufacture had been transplanted from Italy. Hallam, in his "View of the state of Europe during the Middle Ages," says, "The only mention of a manufacture as early as the ninth or tenth centuries that I remember to have met with is in Schmidt (Hist. des Allem, t. 2, p. 146), who says that cloths were

exported from Friesland to England. He quotes no authority, but I am satisfied that he has not advanced this fact gratuitously." Other authorities, viz., De Witt and Meyer, give the date of the commencement of the woollen manufactures about the year 960, or rather sooner. From this date they appear to have pushed their trade with considerable vigour, for there are many concurrent testimonies that in the twelfth and succeeding centuries the Flemish textile manufactures were in a flourishing condition. Many of our English authors of this period testify to the flourishing state of the manufacture in Flanders, for instance, Giraldus Cambrensis, (Itin. Camb. 1-2, chap. 2), who ascribes great skill in it to the Flemings, and states that a colony of them established it in England; also Gervase, of Tilbury, who states that the art of weaving seems to be a gift bestowed upon them by nature. Similar testimony is borne by Ralph de Dicito, and Henry of Huntingdon; and Matthew of Westminster says that "all the world was clothed from English wool wrought in Flanders." This was no doubt an exaggerated boast, but Flemish stuffs were probably sold wherever the sea or a navigable river permitted them to be carried.

Having thus briefly glanced at the textile manufactures among the ancients, to show as nearly as possible their origin and antiquity, we will now proceed to point out a few of the earliest allusions and best authenticated facts to be found on record regarding the manufacture of woollen cloths in England, from the time of the Roman invasion, which is the earliest of which we have any record of the manufacture of textile fabrics being systematically carried on in this country.

The fabrication and dyeing of wearing apparel, of a coarse woollen texture, was unquestionably carried on to a limited extent by the ancient Gauls. And at the time of the Roman invasion of Britain it is recorded that the resi-

dents of the maritime ports of the island, adjacent to the continent, wore apparel made from wool. Cæsar narrates that he found them clothed in drapery similar to that used in Gaul and the Belgic States, where considerable manufacture from wool then existed.

It is a moot point whether the sheep is indigenous to, or imported into, Great Britain. The first mention of English wool we have on record Professor Millar alleges to have occurred about the time that this country was a mere Roman province. Smith, in his "Memoirs of Wool," contends that the first mention of sheep in English records or history was not made till about the beginning of the eighth century; while Professor Archer says that "there is no proof of its introduction, but there are proofs that it existed long antecedent to the Roman invasion and occupation."

It is interesting, however, to know that our conquerors, among the many other lessons they taught us, systematically manufactured wool first in Britain. They established an extensive manufactory at Winchester for the purpose of supplying the Roman army with clothing. This manufactory must have obtained considerable celebrity abroad. Dionysius Alexandrinus writes of it "that the wool of Britain is often spun so fine, that it is in a manner comparable to a spider's thread."

Now the Romans were not likely to have brought wool to this country for the purpose of making it into cloth, and it is therefore only reasonable to conclude that they found it in such abundance and good quality as to tempt them to utilize it.

For the next half dozen centuries after the Romans retired from this country, history is entirely silent upon the subject of textile manufactures. In the ninth century we again light upon it: "The mother of Alfred the Great was a spinner of wool, and also taught her daughters the

art." And we are credibly informed by an old chronicler that King Edward the Elder "sette his sons to schole, his daughters he sette to wool werke," and they employed themselves in spinning, weaving, and embroidery, which "were prudently taught them to fill up the very large vacuities of an unlettered life with an innocent and reputable employment."

From this time forward, even to the commencement of the present century, most of the spinning of wool was done by women, and their industry was only equalled by their skill, it being the pride of a good spinster to make the finest yarn and plenty of it. Several remarkable examples of this skill are recorded, one even by the Royal Society. Mary Pringle, a Norfolk lady, earned this honour, by spinning a pound of wool into 84,000 yards (nearly 48 miles), though this falls far short of the accomplishments of a Lincolnshire lady, Miss Ives, of Spalding, who spun the same weight of wool into 168,000 yards, or 95½ miles of yarn; whilst the ordinary spinners of that time varied from (good) 13,440 yards, to (superfine) 39,200 yards per pound.

It is generally supposed that during the Anglo-Saxon period large quantities of English wool were purchased by the Flemings, who were then, as we have previously remarked, the principal manufacturers of fine cloths for the whole of the European markets. That wool was at this time a commodity of export is rendered highly probable from the high price at which it was sold, compared with the cost of the animal producing it. Macpherson states that in the "laws of Ina, King of the West Saxons, who reigned at the close of the seventh century, a sheep with its lamb is valued at a shilling. In another of Ina's laws the fleece alone is valued at two pennies, that is at one-sixth of the price of the entire sheep and lamb."

The internal trade of England, during nearly the whole of the period to which allusion is now made, was exceedingly limited. No person was allowed to buy anything above the value of twenty pennies, except within a town, and in the presence of the Chief Magistrate (called the king's port-reeve), or two or more witnesses of well-known veracity. The penalty for breaking this curious enactment was the payment of thirty shillings, besides forfeiting the goods so exchanged, to the Lord of the Manor. This regulation took place in the seventh century, and is to be found in the code of laws adopted by King Hlothaere (or Lothair), of Kent.

In the early part of the tenth century an enactment was made in the reign of Athelstane, to the effect that every merchant who shall have made three voyages over the sea with a ship and cargo of his own shall have the rank of thane or nobleman. This wise and liberal proceeding gave an impetus to the commercial transactions of this period, which fully justified the policy of such a step.

King Edgar, during this century, attached such a high value to the growth of wool that he took effectual measures for the suppression of wolves, which had rendered the keeping of sheep an occupation highly precarious and uncertain in all parts of the realm. It is said that very few of these ravenous and dangerous animals were left in the island. This monarch, towards the close of his reign, enforced a law to the effect that a weigh of wool was not to sell for more than half a pound of silver. When we take into consideration the comparative value of money and other articles at this remote period, this enactment indicates plainly the high price which wool must have realized in times prior to the Norman conquest.

On the accession of William the Conqueror to the English throne, a large number of Flemish weavers following in his train settled in various parts of England,

improving very much the manufacture from wool then carried on here, and introducing some entirely new branches of it. Some of these workmen settled in the parish of St. Peter's, Mancroft, Norwich, and are supposed to have introduced into that locality the art of making worsteds. The Normans and Flemings were proverbial for their love of dress, which imparted to their woven fabrics great elegance and fineness, and tended to encourage the improvement of the textile arts, and gave a stimulus to trade.

In the reign of Henry I, a great inundation drove numbers of these Flemish weavers from their native shores, and they sought refuge in this country, the King giving them a hearty welcome, placing a great number of them in the neighbourhood of Carlisle. This was a very fortunate occurrence for the native inhabitants of this district, who were thus taught an improved system of manufacture, for which valuable services the strongest manifestations of envy and animosity were the sole return. In 1110, these Flemish settlers, owing to the latter circumstance, so highly discreditable to the Saxon population, were transplanted into Wales, a district called Ros, and now a part of Pembrokeshire, where they carried on with vigour their useful occupation. They are described by Giraldus Cambrensis as being "excellently skilled both in the art of making cloth, and in that of merchandise." And we are further informed, by William of Malmesbury, that they were a brave, hardy people, equally qualified to handle the plough and the sword, and also skilful in the woollen manufacture, the great staple of their country, so that in every respect they were a very valuable colony, whether considered as a barrier against the enemy, or the first founders of the manufacture of *fine* woollens in England.

Some of these Flemish weavers settled at Worsted in Norfolk, and there commenced the manufacture of stuff goods, which have since borne that name. It seems very

probable that the name "Worsted," as given to the fabrics which now form the great staple trade of Bradford, and the surrounding districts of the West-Riding of Yorkshire, was derived from the name of this Norfolk town, and this derivation is generally accepted as the correct one. There have been three hypotheses as to its derivation. The second supposition is that the word is derived from the Dutch term "Ostade," signifying this particular class of woollen fabric; and that the corruption "Worsted" took its rise from the Flemish weavers establishing it at and giving name to the town.* The writer of the article on the worsted manufacture in Rees' Cyclopædia adopts this; he says that, "as the Flemings introduced the manufacture into England, it is probable our appellation is a corruption of theirs. Ostade was long ago a common name in Flanders, and was probably the surname of some person famous for this branch of the woollen trade, which afterwards was appropriated to an establishment of similar manufactures in Norfolk."

The third derivation is founded upon the conjecture of Archdeacon Nares. In his Glossary, he says, "Worsted is usually supposed to be named from the town so called in Norfolk, where it is therefore thought to have been invented, but woollen thread, yarn, and stuff might naturally be called woolstead, as being the staple or substance of wool, and it appears to me more probable that the town was named from the manufacture, than that from it. Both might easily be corrupted to worsted, by the common change of the letter *l* to *r*. Worsted thread or yarn must have been known as long as the spinning of wool, that is, as long as clothing was used. The town had probably a much later date, and was originally called

* Since this was written I have visited the town of Worsted, and find from the records of the fine old Parish Church, that the name of the town existed long before the Flemings settled there.

woolstead, from being a sted or station for woollen manufactures. This however is only a conjecture, and opposite to the opinion of Skinner and others." Skinner, Camden, and others adopt the first hypothesis, and it seems certainly to have the greatest weight of probabilities in its favour. It is certain the town of Worsted existed in the time of the Saxons. In Doomsday Book it is recorded that in the reign of Edward the Confessor, the lordship of Worsted belonged to the Abbot of St. Bennet, of Holme; and at the great survey, to one of the king's officers, who assumed, according to the custom of the times, the surname of Wursted. This is, therefore, conclusive that if the town derived its name from the manufacture it must have done so in the Saxon times.

The woollen manufacture made such rapid progress during this interesting period of its history, that towards the close of the reign of Henry II., it became extended over the whole kingdom, and companies of guilds of weavers were established in London, Oxford, York, Nottingham, Huntingdon, Lincoln, and Winchester, all of whom paid fines to the king for the privilege of carrying on their manufacture exclusive of other towns. There were also dealers, or merchants, in a great many of the towns, who paid fines to the king in a similar manner for the privilege of buying and selling dyed cloths.

Wool was the great native commodity of England in those days, particularly in the reign of Henry II., when it was mainly converted into cloth by English manufacturers. Dr. Whitaker, in his "History of Craven," makes the following statement as to the value of wool about the close of the twelfth century:—"A sack of wool sold for £6. The sack consisted, according to Spelman, of twenty-six stones, each weighing fourteen pounds. A labourer then received a penny a day, and an ox was worth about thirteen shillings and fourpence; whence it follows that at that

time two and a half stones of wool would purchase an ox. Whereas a labourer will now earn the value of a stone of wool in a week, at that time it would require sixty days, so that poor sheep walks were as valuable as the best land."

At this time cloths were made for exportation as well as home consumption, and the Germans were purchasers of English woollens.

In the patent of incorporation of the guild of weavers in London, already alluded to, the mixing of Spanish with English wool is strictly prohibited; from which some writers infer that English woollen cloths of an inferior texture were all made of English wool, and others that English wool was finer in quality than Spanish. In 1197 a law was enacted for regulating the dyeing and sale of home-made cloths, as well as for the purpose of establishing a uniformity of weights and measures.

On the death of Henry II. the textile arts still continued to flourish, notwithstanding the warlike disposition of Richard I. Even then broad cloth appears to have been made in England. In the *Capitulu Placitorum Coronæ* of Richard I., chap. 28, we find that it is ordered that it shall be all of one breadth, namely, two ells within the lists, and of the same goodness in the middle as the edges.

In the reign of King John the manufactures of England declined very much, and, in consequence, large quantities of foreign cloths were imported. Hence it was that about this time a general safe conduct was granted to all foreign merchants, to enable them to pass to and from England without hinderance or molestation.

During the civil wars, when John and Henry III. successively sat on the throne, the woollen manufacture gradually decayed, and English wools were exported in their raw state to foreign parts. The quantity of wool grown in England must have been very considerable.

Spelman relates that the nobles on delivering in a list of their grievances in 1279 to Edward I., when he was about to embark for Flanders, represented it to be their opinion that one-half of the wealth of the kingdom consisted of wool. Danzel, who perhaps comes nearer the truth, states that the wool of England at this time was equal to a fifth part of the substance thereof.

Although these facts are significant of the increase in the exportation of wool, to some extent the natural result of the decay in our domestic manufactures, till the appointment by Edward I., in the 25th year of his reign, of Peter de Edelmeton as aulnager of cloth throughout the kingdom, leads us to infer that the woollen manufacture was carried on to a greater extent than we should have imagined. At this time only the coarsest kinds of cloth appear to have been made in England, and all the finest descriptions were obtained abroad. We are informed by Dr. Whitaker that the canons in Bolton Abbey, in Yorkshire, visited annually St. Botolph Fair, held at Boston, Lincolnshire, for the purpose of buying cloth. As they received commissions from the neighbouring gentry to make purchases for them, their transactions with the foreign merchants at Boston were larger than they would otherwise have occasion to make. It is a curious fact worthy also of mention, that in the reign of the above-named king the burgesses of Hedon (a place near Hull) had to pay a heavy penalty for not making cloth of the full measurement required by statute.

From the preceding pages it is obvious that the woollen and worsted manufactures flourished to a considerable extent in this country previous to the time of Edward III., and that the commonly received notion attributing to him their first establishment is erroneous. However, he did much to encourage and advance these branches of the trade, and from his reign may be dated a new era in their

history. In 1331, this sovereign invited, by special grant skilful Flemish weavers, dyers, and fullers to come over and settle permanently in England, with an assurance of his special favour and protection. A considerable number of them responded to the King's invitation, and settled by his directions where the wool grown in the district was suitable for the particular kind of cloth or stuff fabricated by these artisans. The worsted weavers were, according to this arrangement, located in Norfolk, Suffolk, and Essex, having Norwich for their chief seat or mart; others of them settled at Kendal, Halifax, Manchester, and the West of England. Fuller, in his Church History, gives a very racy and graphic account of the introduction of these foreign weavers, and their settlement in this country.

To further encourage the extension of the manufacture from wool, a Parliament convened in the middle of March, 1337, enacted: 1st, That it should be a felony to transport any wool of English growth beyond the seas until it be otherwise ordained. 2nd. That all foreign clothworkers should be received from whatever parts they came, and have privileges allowed them. 3rd, That none should wear any cloths made beyond the sea except the Royal Family. The words "until it be otherwise ordained," contained in the clause prohibiting the export of wool, render it apparent that this was only a temporary expedient for the encouragement of English manufactures, for this prohibition was from time to time dispensed with by the Crown, by virtue of the writ *Non Obstante*, much used in those days. The prohibition of the importation of foreign cloth, except for the Royal Family, was also rescinded at a later period of this reign.

During this reign staples* for wool were established

* Staple in its original sense denoted a place or port to which goods were brought for payment of customs, before they could be sold or exported. Those who exported were termed merchants of the staple.

in various parts of the kingdom, which were, however, abolished by a Parliament assembled at York in the year 1334, with the general consent of the nation. About the same time the foreign merchants, who, in consequence of a slight rupture with the English people, had ceased to have any transactions with them, were induced to resume mercantile operations, by the King confirming a charter originally granted in 1303, to which was added an assurance that no "undue prises, exactions, or arrests" should be inflicted for the future; and that no contributions should be levied on them for the Royal use, or the benefit of the State, without their sanction being obtained even in the case of war breaking out.

The Flemish manufacturers found at this time their most formidable rivals in the Brabanters, who had made great progress in the woollen and worsted manufactures. Large quantities of wool were exported from this country both to Brabant and Flanders, although the people of the former country were only allowed by law to purchase at the towns in England appointed for the sale of wool, and only to such an extent from time to time as was sufficient for half-a-year's comsumption, the precise quantities required having to be sworn by two deputies from each of the principal manufacturing towns, furnished with the Duke's letters patent.

Abundant testimony may be found in the records of the period that the produce of wool had, in the days of Edward III., reached an immense amount. From an Act of Parliament passed in the twenty-seventh year of Henry VI. we gather that in the time of Edward III. the subsidies and customs of the staple of Calais amounted to the enormous sum of sixty-eight thousand pounds yearly, of which by far the greater part would arise from the export of wool.

As a striking indication of the value of wool in

England at this important era in the annals of the woollen manufactures, and the immense profit realised by its exportation, owing doubtless to the great demand for it abroad, it may be mentioned that the historian of Edward III. states that the King in November, 1337, "having taken up wool throughout all England, for which he gave the proprietors tallies at the rate of £6 per sack," shipped 10,000 sacks of it for Brabant, "where they were sold at £20 each." A great deal of other interesting information may be collected respecting the value of wool at this period, but this scarcely comes within the scope of the present work.

On the death of Edward III. the woollen manufacture, though somewhat checked in its progress, still continued to flourish to a great extent in the days of his grandson. While Richard II. occupied the throne many enactments were made in favour of foreign merchants settling and trading in England, who had in former periods, to satisfy the home merchants, been restricted in their commercial intercourse with this country.

Multitudes of passages in English History prove that from the first settlement of foreign weavers and merchants in this country, they were viewed with suspicion and dislike. In the days of Edward III. it became necessary to give these weavers especial letters of protection to save them from the violence of the people, who, notwithstanding, in some places gave unrestrained vent to the innate jealousy and hatred of the foreigner—strongly characteristic of the English in those days—broke the looms and other untensils of the intruders, and committed outrages upon their persons.

It is narrated in the year 1344, that the maltreatment of the foreign weavers residing in London by the native inhabitants grew so oppressive and riotous that a proclamation was made by the Mayor and Sheriffs of the

City, in obedience to strict orders from the King, that any person doing the least injury to a foreigner should be *imprisoned for the offence.* This proclamation was made very opportunely, for had these skilful artisans been driven from our dominions, in order to escape the violence of prosecution which seemed to threaten them at one time with remorseless fury, England would not have made the rapid progress she did with the textile arts. Such, however, were the skill and enterprise of these foreigners, that to them we are undoubtedly indebted for the foundation of our great national industry. To this and to events which we shall have to notice at a later period, England undoubtedly owes her manufacturing superiority over the inhabitants of any other portion of the globe,—even those European states that were once the monopolists of the arts, both of design and production,—which has since made Englishmen "the wonder and envy of the world."

There is no doubt the rule of the House of Lancaster proved detrimental to the progress of the manufactures. The reigns of Henry IV. and his son Henry V. were of such short duration, and the latter consisted so much of military conquest, that they are almost a blank in the commercial history of the country.

From the date of Henry IV. ascending the throne to the battle of Bosworth Field, England had, during the larger portion of the interval, been a scene of war and bloodshed; and owing to the intestine commotions, and the artisans being arrayed under the banners of the hostile houses, the clothing arts gradually languished and decayed, so that the fame of England abroad, for woven productions, became at last from the smallness of their export well nigh extinct.

The boroughs and great towns of the kingdom were in the middle ages, not only cities of refuge for the feudal

slaves of the great landowners, but the large demand and high remuneration for labour induced the country people to apprentice their children in them, thereby causing a scarcity of hands for cultivating the soil. To remedy this grievance of the landlords, Parliament, in the seventh year of Henry IV., prohibited "any man or woman from putting their son or daughter to be apprentice within any city or town, unless they had lands or rents to the value of twenty shillings at the least by the year." When one bears in mind the value of money in those days, the sum of twenty shillings a year formed a considerable income, and consequently kept down considerably the number who were at liberty to apprentice their children.

After Henry VII. had firmly seated himself on the throne, and united the claims of the rival houses of York and Lancaster, by his marriage with Elizabeth of York, he appears to have endeavoured to restore the clothing arts, as well as the general trade of the kingdom, to their former condition; and to encourage the enrichment and elevation of his subjects by means of trade and commercial enterprise. He likewise invited numerous Flemish clothing manufacturers to settle in his dominions; and during his reign the woollen and worsted trades, from a state of decay, spread and increased so greatly as to lead some authors into the mistake of attributing to him the introduction of these arts into the kingdom.

This monarch in various ways showed his anxiety to promote the manufacture of wool and the commercial prosperity of his subjects. Among other things—although the export of wool was not entirely forbidden—soon after his coronation it was declared, "that no person during ten years following should buy, take, promise, or bargain for any wool before the fifteenth day of August in each year, except such persons as intended to make cloth or yarn thereof; nor any merchant stranger before the second of

February after," thus giving the home manufacturers an opportunity of satisfying their own requirements first, and then the residue might be sold to foreign merchants, who, however, paid the heavy custom of three pounds six shillings and eightpence per sack, double the duty imposed upon the home manufacturers.

During the reign of Henry VIII. the manufacture appears to have declined, and although numerous attempts were made by the legislature to promote its increase, it does not seem during his reign to have recovered from the state of decay into which it had fallen. Great complaint is made at the dishonest expedients resorted to by the manufacturers, in the making and finishing of their goods, and numerous provisions are made in the statute book to prevent and guard against such injurious practices. Again during this reign the question of the export of wool seems to have received some attention. Lord Herbert, in his "Life of Henry VIII.," says "It was provided that *no unwrought* wool shall be exported out of the kingdom, for the encouragement of the woollen manufacture." James, in his "History of the Worsted Trade," says this statement is incorrect, "for although, in consequence of the enclosure of lands and the conversion of it into tillage, the produce of wool had diminished in comparison with that of earlier times and become barely sufficient for the home clothier, so that the export of it had nearly ceased, yet the statute book at this time did not contain any prohibition against the exportation of unwrought wool, except that of Norfolk sheep."

We now come on to the time of Elizabeth, for although with the fifteenth century the Middle Ages are supposed to terminate, yet the interval was one of mere transition, and with the accession of Elizabeth to the throne a new era seems to have commenced. Events also occurred on the Continent which gave a great impulse to, and in many

respects changed, the character of the manufactures in this country. The persecution of the Protestants in France and the Netherlands, 1567-8, drove thousands of them into this country, bringing with them a variety of manufactures, which they established here. The manufacture of woollens must at this time have risen to a considerable extent. Anderson, in his "Progress of the Arts and Sciences," says that in 1582 the value of woollen cloth exported from England amounted to £200,000 annually, and other writers have placed it at a very much higher figure than that. Smith, in his "Memoirs of Wool," puts the value of exports to Antwerp alone during the reign of Elizabeth at £750,000 sterling, but this doubtless includes worsted as well as woollen goods.

England at this time appears to have superseded the Netherlands in the quality of their cloths. This has been attributed to the quality of their wool, which even so late as the sixteenth century is said to have been the finest and most valuable in the world, exceeding in quality the wools of Spain, which were largely used in the Netherlands.

Improbable as it may appear, it is nevertheless certain, that although this country had obtained such a position in the manufactures, the best methods of finishing and dyeing, especially of the finer descriptions of cloths, were very little known. Smith, in his "Memoirs of Wool," quoting from Coke, says "The English at this time were not skilled in the art of dressing and dyeing English woollen manufactures, but, after they were made here, they were vended into Holland, where they were dressed and dyed." Logwood had at this time come into use, but from some cause, probably its improper application, it was, in 1597, forbidden by law to be used.

From this time forward the manufactures of England made rapid progress, and marvellous indeed was the rapid increase of English trade. New branches of industry

sprang up and developed themselves in rapid succession, and thus laid the foundation of a national prosperity the like of which the world had never witnessed.

The introduction of the silk trade into this country appears to have taken place in the early part of the seventeenth century. Anderson, in the book before quoted, viz., the "Progress of the Arts and Sciences," says that silk-worms were first brought into England in the year 1608, and the first broad silk was manufactured in the year 1620. About this time (1614), according to the same authority, the dyeing of cloth in the wool was first invented; and in 1619, tapestry work was first introduced into England.

Shortly after this the French commenced the manufacture of fine woollen cloth, the first establishment, started in 1646, being at Sedan, under the patronage of Cardinal Mazarine. In a very few years this branch of industry must have made rapid progress, for we very soon find complaint made that the worsted manufactures of that country seriously effect the prosperity of our own. Not only in woollen and worsted articles, but in other goods did the French compete heavily with the English manufacturers. And to encourage their own production they laid an impost of fifty or sixty per cent. upon our drapery, constituting an almost express prohibition.

To counteract in some measure the injurious effects to our textile manufactures arising from the importation of French commodities, the legislature directed that no person should be buried in any woven material except made of wool, thereby intending to prevent the custom of using French linen and lace for the purpose, which at this period was much in vogue, and carried to a profuse length in burials. By virtue of this prohibition, fine worsted stuffs and flannels became common wrappings for the dead; and a vestage of the ancient practice remains in some districts to the present time.

Afterwards Parliament, in consequence of the loud and incessant complaints of the nation, altogether prohibited, in the early part of the year 1678, the importation into England of all French merchandise whatsoever. Immediately after this our manufactures from wool began to prosper to an amazing extent.

In the meantime the silk manufactures had continued to progress in this country so rapidly that, in the year 1629, the silk throwsters of London were a sufficiently numerous and important body to be incorporated under the style of master, wardens, assistants and commonalty of silk throwsters. And it is said, in 1663, there were forty thousand men, women, and children employed in silk throwing in and near London. The woollen manufactures, too, had been quite alive to their own interests, and, in 1667, the dyeing and dressing of cloth was perfected in England by one Brewer, from the Netherlands.

Shortly after this, events transpired to weaken the manufacturing energy of France. Louis XIV., guided by injudicious councils, determined to revoke the Edict of Nantes, thereby depriving his Protestant subjects of their rights and privileges. In consequence of this revocation immense numbers quitted their native country, carrying with them their wealth and industry, and no less than 70,000 of them are said to have settled in Great Britain.

These refugees introduced here many new methods and improvements in the textile arts, and added greatly to our increasing importance as a manufacturing nation. The whole number who for conscience' sake quitted their native country is said to have been no less than 800,000.

The influx of these refugees to our country no doubt gave the greatest impetus to our manufacturing industries, and we are doubtless largely indebted to the intolerant

bigotry and persecuting spirit of our Continental neighbours for our rapid progress at this time.

That at the close of the seventeenth century the textile industries of England had grown to an enormous extent is evidenced by the fact that competent authorities valued the wool shorn in England at £2,000,000 sterling, and the manufactures from it at £6,000,000. Again, a tolerable notion of the extent of the English trade may be formed from the fact that the merchants of London alone numbered nearly 2000, in addition to those of other towns, who were both numerous and wealthy. For the next half-century, although at particular periods the trade was in an unprosperous condition, on the whole the manufactures from wool were a growing and improving source of national income; evidence of this may be found in the value of the exports at different periods. In the year 1700 these exports did not quite reach £3,000,000 sterling; in 1708, even when the nation was at war, they exceeded that sum. After many fluctuations they attained, in 1736, the remarkably large sum of upwards of £4,000,000 sterling. Between this time and the termination of the half-century they fluctuated considerably, standing, however, at the latter period at considerably over £4,000,000,

We now arrive at a period which is remarkable in the history of the textile manufactures, both for the inventions and improvements that were made in the various processes, and for the remarkable development which took place. For thousands of years the hand of man had directly fashioned the material of his apparel, but now for the first time automatic machines began to be called into use—machines whose wonderful combinations, whose power of production, so infinite and various, so prodigious in their operations and results, awaken in the mind the most profound feelings of wonder and astonish-

ment. The inventions of Kay, Hargreaves, Crompton, Arkwright, Watt, Cartwright, and a host of others who sprung up almost simultaneously, led the way to the production in abundance, and at little cost, of beautiful and durable materials of apparel for the whole of the civilised world.

The distaff and spindle of the ancients were originally the only instruments employed for converting wool into yarn. The one-thread wheel was next brought into use; the date of its introduction here, however, seems to be lost in obscurity, but this and the rude teak wheel of Hindostan had evidently a common origin.

At the commencement of the eighteenth century, there were three kinds of instruments used for spinning all kinds of material. First the *Rock*, as the ancient distaff and spindle were called in England. In the process of Rock spinning the spinners drew out the thread from the end of a sliver of combed wool, and communicated the necessary motion to a rough kind of spindle by twirling it between the right hand and thigh, allowing the spindle to revolve when suspended by the thread, which was gradually lengthened by the fingers. By this primitive process a yarn of the most delicate quality could be produced. No doubt the process would be tedious and the production small, and long and incessant practice would be required to acquire the skill and delicacy of manipulation necessary to overcome the difficulties arising from the rudeness of the instrument, and to produce the fine quality of yarn for which the spinsters of these times were famous.

Next came the common one-thread wheel, which, up to the end of the eighteenth century, was ordinarily used in spinning wool. This instrument was nothing more or less than the above-named loose spindle, mounted in a frame and turned by a cord passing over the rim of

a large wheel, thus the spinners' hands were left freer than by the loose spindle method to draw out the thread, consequently it had a capability of production which was evidently its main advantage. In this kind of spinning the operator took the wool with the finger and thumb of the left hand, a few inches distant from the spindle, and drew it towards her, while with the right hand she turned the wheel ; she thus extended and twisted repeated portions, and as they were twisted she wound them upon the spindle, guiding the thread with her left hand.

The third kind of machine was also in use at the commencement of the eighhteenth century and was named the *small* or *Saxon wheel.* This, though a more perfect machine than the last-mentioned, was only applicable, except in particular instances, to the spinning of flax. In this machine evidently lay the germs of Arkwright's invention. The spindle in the Saxon wheel had on it a bobbin, on which was wound the thread; round the bobbin a flyer revolved at a greater speed than the bobbin itself, which gave the thread the necessary twist. The wheel being very small, it received its motion from a treadle. Spinning by this wheel seems to have formed the favourite occupation of lady spinsters during the seventeenth and eighteenth centuries.

It appears that previous to the eighteenth century, an attempt had been made to spin by a process making some approach to the apparatus of modern times. In the year 1678 a patent was taken out for "a spinning machine whereby from six to one hundred spinners may be employed by the strength of one or two persons to spin linen and worsted threads, with such ease and advantage that a child three or four years of age may do as much as a child of seven or eight years old, and others as much in two days as without the invention they can do in three days." It appears that this invention only

shortened the labour by about one-half; but it leads one to the conclusion that it contained the embryo principle of the wonderful inventions which succeeded it.

The origin of spinning by means of rollers, like every other great invention, is involved in considerable doubt. This arises probably from the numerous gradations by which the machine was brought to maturity. It has been generally supposed that the process of spinning by rollers originated either in the mind of Arkwright or of a person named Highs; but Mr. Baines, in his "History of the Cotton Manufacture," proves that the principle had been discovered, and to some extent carried out, at least thirty years before, by John Wyatt, who patented a machine containing this principle in 1738. This machine first essayed its powers in 1741 at Birmingham, where it was turned by a gin, worked by a couple of asses, and attended by ten girls; but owing to the poverty of Wyatt and his partner (one Lewis Paul), the concern was, after a short trial closed. Another factory was opened at Northampton by Mr. Cave, the proprietor of the "Gentleman's Magazine." This appears to have been on a larger scale than that of Wyatt and Paul, and was driven by water-power. It appears to have been carried on up to the year 1764, when it was given up as an unprofitable concern.

There is some difficulty in ascertaining correctly to whom we are indebted for the next step in the improvement of spinning machinery, Arkwright or Highs. The evidence as given at the trial which took place in the year 1785, to try the validity of Arkwright's patent, seems to point to Highs as having been in advance of Arkwright in this matter; indeed, Arkwright appears to have received information from Kay, the clockmaker, of the principle of construction in High's machine, which he improved and perfected in many respects.

From whatever source Arkwright obtained the first idea for his spinning machine, it must be admitted he used it well, and proved himself one of the most remarkable men of his day, and to his ingenuity and perseverance may be attributed the remarkable revolution which took place in the textile manufactures, and placed England in the first rank as a manufacturing nation.

Nearly contemporaneous with the invention of Arkwright, James Hargreaves invented the spinning jenny. This machine exercised considerable influence on the manufactures from wool, as Arkwright's had done on the cotton manufactures. Another spinning machine came into existence also about this time, combining the principle of Arkwright's drawing roller with Hargreaves' jenny. This invention owes its existence also to a Lancashire man, Samuel Crompton, a weaver residing near Bolton. Of the value of this invention no estimate can be formed. Yet Crompton himself benefited little by it, and his life was made miserable by the spy system and persecution which ultimately compelled him to give his machine to the public on the faith of promises which were never fulfilled, and by the ingratitude of those who grew rich around him by the means which he had placed in their hands.

Mr. Epinasse gives an admirable narrative of Crompton's career in his "Lancashire Worthies."*

From this time the improvements in spinning machinery have been both numerous and valuable, as the present state of perfection to which they have been brought amply testifies.

We now come to the class of machinery with which this work is more directly connected, viz., the loom. It is claimed for the Egyptians that they were the first inventors of weaving, and certainly the earliest looms of which we

* "Lancashire Worthies," by Francis Epinasse. Second Series. London: Simpkin, Marshall & Co.

have any evidence are those of the Egyptians. Of these they had two kinds, one horizontal and the other perpendicular. The shuttle in the form of the present day was unknown to them; but, instead of the shuttle they used a stick with a hook at the end, to pass the thread of weft through the warp; this stick also had to act as a batten, for they had no slay or batten, such as is used now. "The use of treadles was also unknown, and the threads of the warp are kept apart by sticks,"* so that the sticks had to answer all the purposes of healds, treadles, slay, and shuttle. On the perpendicular loom, which consisted simply of an upright frame with warp threads stretched from top to bottom, the practice of the Egyptians was, according to Herodotus, contrary to that of other nations, to push the weft downwards, and this is shown in many of the paintings depicting their method of making cloth; but it appears from a representation found at Thebes, of a man employed at weaving, that he pushes the weft upwards. It is therefore evident that both methods were employed by them. The horizontal loom, however, appears to have been mostly in use. On the tomb of Beni Hassan there is a representation of a weaver at work with a horizontal loom. "It is fastened to four pegs pushed into the ground, and the workman sits on the part of the web already finished, which is a small chequered pattern of yellow and green."† This loom in some respects resembles the loom employed by the Hindoo weavers, and which has very probably been used by them for thousands of years. The following is a description of the Hindoo loom, taken from Martin's "Circle of the Mechanical Arts," p. 239:—The loom consists merely of two bamboo rollers, one for the warp and the other for the web, and a pair of gears. The shuttle performs the double office of shuttle and batten, and for

* Kenrick's "Ancient Egypt." Vol. 1. p. 216.
† "Minutoli." Vol, 2. p. 34.

this purpose is made like a huge netting needle, and of a length somewhat exceeding the breadth of the cloth. This apparatus the weaver carries to a tree, under which he digs a hole large enough to contain his legs, and the lower part of the gear. He then stretches his warp by fastening his bamboo rollers, at a due distance from each other, on the turf, by wooden pins. The balance of the gear he fastens to some convenient branch of the tree over his head. Two loops underneath the gear, in which he inserts his great toes, serve instead of treadles, and his long shuttle, which also performs the office of batten, draws the weft through the warp, and afterwards strikes it up close to the web."

It is very evident that the implements used, not only by the early Egyptians, but by other contemporaneous nations, and even by the Hindoos of the present time, were of the rudest possible character, and nothing but the most exemplary patience, dexterity, and great delicacy of hand, acquired by long traditionary habit, can account for the extraordinary beauty and fineness of their textile productions.

The Greek and Roman nations in the first period of their history appear to have used looms somewhat similar to those of the Egyptians. The Romans when they had made some advance in the arts, used a loom somewhat nearer approaching the loom of modern days, inasmuch as though they still preserved the perpendicular stretching of the threads, the weft was thrown through by means of a shuttle more nearly approaching the style of shuttle now used. In this loom the operator separated the threads of the warp by means of straight canes passed through the warp; the number being regulated by the pattern being woven on the cloth, whether plain or otherwise. For batten or slay, they used an instrument held loose in the hand, called a *spatha*, formed like a wooden sword, to

drive the weft home up to the cloth, while with the other hand they passed the shuttle (rather boat-shaped) carrying the weft through the warp threads thus separated. This is the first indication we have of the use of the shuttle. In the fourteenth century we find a still nearer approach to the modern loom; instead of the warp being perpendicular, we find it is stretched horizontally in the loom, and a species of healds and treadles used for separating the warp threads to make a passage for the shuttle, which is thrown through with the hand. This continued to be the method of weaving for several centuries. The introduction of the fly shuttle, said to have been invented by John Kaye, of Bury, who, as a reward for his ingenuity, was driven from that town and was obliged to take refuge in France, was the next great step in weaving; but this for a very long time did not altogether supersede the use of the old hand shuttle. Not many years ago the writer saw this ancient method of weaving with the hand shuttle in full practice among the Welsh. The introduction of the changing shuttle box must have followed shortly after the introduction of the fly shuttle; thus enabling the weaver to change the colour of his weft without stopping in his weaving. Improvements now began to follow each other more rapidly. Machines were invented for separating the warp threads so as to produce patterns of greater extent. Various machines were invented for working large numbers of healds, the principles being used at the present day in power looms. Another method known as the draw loom enabled the weaver to weave more extensive and intricate patterns than could possibly be done by healds, the disadvantage of this loom being that a second person was required to draw the cords, to open the warp, and thus enable the weaver to proceed with his operations. An invention by one David Bonnar in 1803, however, dispensed with this labour, by using a number of iron combs which enabled the weaver to

perform the work himself. This invention was afterwards improved upon, and various kinds of draw looms came into use with varying success. But the great invention of Pierre Jacquard outstripped them all, and placed a power of producing patterns in the hands of the weaver which is practically without limit, thus enabling the productions of the loom to become what they more frequently ought to be, viz., works of art.

Early attempts appear to have been made to produce an automaton loom. The first of which we have any record was put up at Dantzick, in Poland. It is thus described in "Human Industry, or History of the Manual Arts," a work published in the year 1661. "In Dantzick, in Poland, there was set up a rare invention for weaving four or five webs at a time without any human help; it was an automaton, or engine that moved of itself, and would work night and day, which invention was suppress because it would prejudice the poor people of the town, and the artist was made away secretly, as 'tis conceived, as Lancellotti, the Italian abbot, relates out of the mouth of one Mr. Muller, a Polonian, who had seen the device." From this it is apparent that the idea of the power loom is very old. A few years later than this, viz., in the year 1678, a loom was constructed by a Frenchman named De Gennes. This loom is described in the Transactions of the Royal Society, and in the main features exhibits some resemblance to the modern power loom. The description is as follows:—"The advantages of this machine are these: 1. That one mill alone will set ten or twelve of these looms at work. 2. That cloth may be made of what breadth you please, or at least much broader than any which has hitherto been made. 3. There will be fewer knots in the cloth, since the threads will not break so fast as in other looms, because the shuttle that breaks the greater part can never touch them. In short, the work will be carried on quicker and at less expense. Instead of several

workmen, which are required in making of very large cloths, one boy will serve to tie the threads of several looms as fast as they break, and to order the quills in the shuttle."

From some cause or other it does not appear that this machine, although it promised so many advantages, ever came into practical use, or rendered any very great services to the country or the trade. Another loom was made by Vaucanson, and came into operation in 1762, in a weaving factory at Manchester, erected by a Mr. Gartside; but this did not succeed, and was soon disused. Hitherto all attempts to attain this end had been futile, and led to no practical result. To the Rev. Edmund Cartwright must be conceded the distinguished merit of originating the present power loom, which has effected a complete revolution in the weaving department, and increased the producing powers of our textile manufacturers to a degree that could never have been anticipated, even by its inventor. The following graphic account of the origin and completion of this useful and valuable invention was given by Cartwright himself to Mr. Bannatyne, the author of the article on the Cotton Manufacture, in the "Encyclopædia Britannica." "Happening to be at Matlock in the summer of 1784, I fell in with some gentlemen of Manchester, when the conversation turned on Arkwright's spinning machinery. One of the company observed that as soon as Arkwright's patent expired so many mills would be erected, and so much cotton spun, that hands could never be found to weave it. To this observation I replied, that Arkwright must then set his wits to work to invent a weaving mill. This brought up a conversation on the subject, in which the Manchester gentlemen unanimously agreed that the thing was impracticable; and, in defence of their opinion, they adduced arguments which I certainly was incompetent to answer, or even comprehend, being totally ignorant of the subject, having never at that time seen a person weave.

I controverted, however, the impracticability of the thing, by remarking that there had been lately exhibited in London an automaton figure which played at chess. 'Now you will not assert, gentlemen,' said I, 'that it is more difficult to construct a machine that shall weave, than one which shall make all the variety of moves which are required in that complicated game.' Some little time afterwards a particular circumstance recalling this conversation to my mind, it struck me that, as in plain weaving, according to the conception I then had of the business, there could only be three movements, which were to follow each other in succession, there would be little difficulty in producing and repeating them. Full of these ideas I immediately employed a carpenter and smith to put them into effect. As soon as the machine was finished, I got a weaver to put in the warp, which was of such material as sail cloth is usually made of. To my great delight a piece of cloth, such as it was, was the produce. As I had never before turned my thoughts to anything mechanical, either in theory or practice, nor had ever seen a loom at work, or knew anything of its construction, you will readily suppose that my first loom was a rude piece of machinery. The warp was placed perpendicularly, the reed fell with the weight of at least half a hundredweight, and the springs which threw the shuttle were strong enough to have thrown a Congreve rocket. In short, it required the strength of two powerful men to work the machine at a slow rate, and only for a short time. Conceiving, in my simplicity, that I had accomplished all that was required, I then secured what I thought was a most valuable property, by a patent, dated 4th of April, 1785. This being done I then condescended to see how other people wove, and you will guess my astonishment when I compared their easy mode of operations with mine. Availing myself, however, of what I then saw, I made a loom in its

general principles nearly as they are made now. But it was not till the year 1787 that I completed my invention, when I took out my last weaving patent, August 1st of that year."

There were, as may be readily inferred, many imperfections in Cartwright's loom, and although the rev. doctor made subsequent attempts to remedy them, for which he took out other patents, the last of which is dated 13th November, 1788, and not the first August in the preceding year, as erroneously stated in the foregoing letter, the consequence of these imperfections was the failure of a weaving factory set up by Dr. Cartwright at Doncaster. In the year 1790 two gentlemen named Grimshaw, of Manchester, obtained a licence from the inventor, and brought into use his power loom, and although they made many improvements in it, their project did not succeed. Dr. Cartwright's plan accordingly slept until the expiration of his patents destroyed all hope of his deriving any benefit from them. In the year 1808 he presented a petition to the House of Commons, backed by a memorial signed by nearly all the principal manufacturers of Manchester and its neighbourhood, and a committee was appointed to consider it, and upon the evidence reported by this committee the House proceeded to vote to Dr. Cartwright the sum of £10,000, as some compensation for his outlay and disappointment. It is said that Dr. Cartwright had expended the sum of between £30,000 and £40,000 in trying to make his invention a success.

Soon after this time Dr. Jeffray, a physician, of Paisley, invented a power loom, very similar in construction to Cartwright's. It had, however, an advantage over Cartwright's in means for preventing the breakage of the weft. This was improved upon again by a person named Miller, of Dumbartonshire, who substituted for the spring in throwing the shuttle the direct action of the motive power. Since that time invention has followed upon invention;

the loom has been brought to a high state of perfection, and may now be considered as beautiful and complete a machine as could well be put together, and produces work which would have astonished in no small degree the knights of the shuttle of less than a century ago.

Such is a brief history of one of the arts which plays a part of no inconsiderable importance in civilised life, and which exercises considerable influence on the tastes of individuals; for by raising the standard of excellence in articles of dress, and making the product of the loom artistic as well as useful, the standard of taste must also be raised. Dress has undoubtedly an influence on the mind of the wearer. Therefore, an elevated taste in dress not only indicates taste in the wearer, but also assists materially in forming or developing that taste.

The object of this work, however, is not to attempt to educate the taste either of those who design or use textile fabrics, but to deal with the practical application of such taste as the wearer or designer may possess in the production of textile fabrics, by dealing with the technicalities of the art of weaving in such a manner that any one engaged in the trade may make himself master of his craft and ascertain the reason why he does certain things in certain ways, and do his work upon intelligible principles, instead of by mere haphazard or rule of thumb.

WEAVING.

Weaving is the art of combining threads, yarns, filaments, or strips of different material so as to form a cloth or fabric. This combination may take a variety of forms, according as the intention is to produce plain or fancy fabrics.

To produce this combination of threads a number of processes or operations require to be gone through, these operations varying only in detail in the production of different fabrics, the principle remaining the same in all cases. Before entering fully into the details of the actual process of weaving, we shall just glance at the preliminary processes required, and at the nature of the machinery used in the operations.

For the ready and rapid combination of threads they are divided into two sets or classes, which are generally known as warp and weft, one set consisting of the threads which run longitudinally through the piece of fabric, and which is termed the warp, the other set being thrown or placed transversely, and termed the weft. The longitudinal or warp threads are first prepared by arranging the required number of threads of the desired length side by side, so that they may be placed in the loom ready for the process of weaving. This is what is known as warping, or making the warp.

The first process necessary after the spinning of the yarn, for the preparation of the warp, is, that the yarn should be wound upon bobbins, or in the case of yarns that have not undergone the process of dyeing or stoving, or any other process, it may be warped direct from the cop or bobbin upon which it has been spun. The usual method

of warping is by means of what is known as the *warping mill.* This warping mill consists of a huge skeleton reel, or frame, mounted on a vertical axis, and moved round by means of an endless band, which connects the bottom of the axis with a wheel which is under the immediate control of the warper, whether the mill be driven by hand or steam power. A number of bobbins, in proportion to the number of ends or threads of which the warp is to consist, are placed in an upright frame, at a convenient distance from the mill. This frame consists of a number of divisions just wide enough to hold the bobbins horizontally; the bobbins are placed in the divisions upon iron pins; the ends of the pins resting in the frame, so as to allow the bobbins to revolve freely upon them. The threads are now taken from the bobbin and passed through an instrument called a *jack* or *heck-box.* This jack is placed between the bobbins and the warping mill, and is made to slide up and down on an upright post, or between two posts; it is suspended by a cord which passes over a pulley, and is made fast to the central axle of the mill, so that as the mill revolves a portion of the cord is wound on the axle, and thus the heck or jack is slowly raised from the bottom to the top; and when the mill is turned the reverse direction it descends by means of its own weight. The heck-block contains a number of steel pins, each having an eye at the upper end, through which a warp thread is passed. Each alternate pin is mounted in a separate frame, which are so constructed as to be raised alternately, for the purpose of making a lease in the warp, so as to enable the weaver to take each thread separately and spread them on the beam for the actual process of weaving. When the threads are passed through the eyes of the heck, their extremities are tied together, and fixed on a peg attached to the mill. The mill is turned a little until the lease pegs come nearly opposite the heck. The warper then lifts half

the heck-frame, and passing the forefinger of the left hand through the open space thus formed in the threads, drops that half and raises the other half. Through this he passes the thumb of the left hand. By this process each alternate thread of warp is made to cross each other, thus forming the lease, which is now put upon the lease pegs of the warping mill. The mill is now made to revolve, and by the arrangement previously described the heck gradually lowers, thus winding the warp round it in a spiral form until sufficient length has been wound on, which is easily determined by the number of revolutions made by the mill, the circumference of the mill being known. The warp is again passed over lease pegs at the bottom, but this time, instead of being divided in alternate ends, it is divided in beers, half-beers, or porties, each consisting of a given number of ends, according to the custom of the district. The process is repeated a number of times until a sufficient number of ends have been put together to make up the warp. The leases are then secured by bands being threaded through them and tied securely. The warp is then removed from the mill, and in the case of a cotton warp, is made up into a huge ball, or if a woollen warp, it is linked up in the form of a chain to keep it in a compact form, and to prevent the threads from being shaken and so intermixed as to become afterwards inseparable. After undergoing a dyeing or sizing process the warp is taken possession of by a beamer or dresser, whose business it is to wind it upon a beam or roller, each thread being separated and laid side by side as nearly as possible, as they go round the beam, and in the case of a fancy pattern, such as a check or a stripe, the various colours of warp must be placed in their proper order.

When the warp has been regularly wound on the beam each thread must be drawn through the eye or loop of the healds, and afterwards through the slay, and, as will be

afterwards shown, upon this part of the business depends in great measure the extent and variety of the patterns which may be produced. The warp is now ready for the loom, and before proceeding any further it will be well to give some description of this most important piece of machinery.

The great variety of looms in use in the different branches of trade in this country renders this a somewhat difficult task, but to obviate this difficulty as far as possible, I shall deal with general principles rather than with actual details, and where reference to a loom is necessary, I shall take one of the fast-going looms as my model. But before going into details of the power looms I shall just glance over the system of hand-loom weaving, because, although the hand loom is now rapidly going out of use, the principles of weaving both by hand and power are precisely the same, and there are some things which may be more readily explained by a reference to the hand loom than they can by the power loom; but in these details I shall be as brief as possible.

THE LOOM AND ITS ACCESSORIES.

As mentioned in the first chapter of this work, the loom of the ancients was a very simple contrivance, consisting merely of a frame in which to stretch the warp, and a stick which answered all the purposes of healds, shuttle, and batten, but by degrees separate articles came to be used to perform the various parts of the operation. The first and one of the most important parts of the loom to claim our attention are the healds. By means of these the warp is separated to allow the shuttle to pass and re-pass through it, and it is by the arrangement of the healds and the way in which the warp is drawn through them that any pattern is formed on the cloth. The first form of heald introduced, and known as the clasped heald, is shown at

Fig. 1, and consists simply of two long loops, linked or passed through each other, and then each passed over a flat wooden shaft, and made secure to a waxed band, known as the ridge band, the object of which is to keep each loop in its proper place. The loops are placed at such distances apart as to regulate the number per inch required. The next form, as shown at Fig, 2, has an eye formed by the

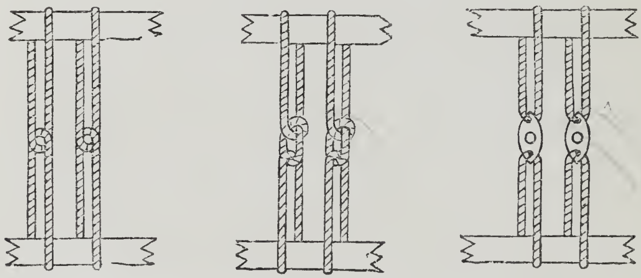


Fig. 1. *Fig.* 2. *Fig.* 3.

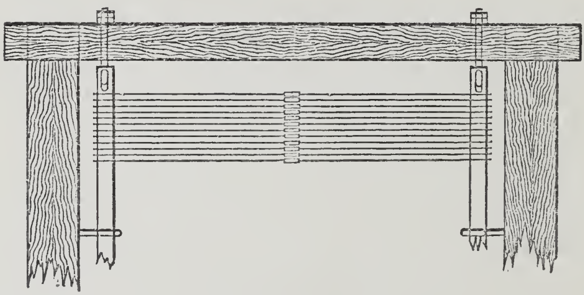


Fig. 4.

upper loop being knotted at a short distance from where it links with the lower half; the kind shown at Fig. 3 has a metallic eye; and Fig. 4 is a wire heald, made of small twisted wire, a small loop being left in the centre for the thread to pass through, and a larger one at each end for the shafts.

The mode of working the healds in the hand loom for weaving plain cloth is shown in Fig. 5. This is done by

means of treadles and levers; A A are the treadles, each of them being suspended by a cord from the long levers B, working on a pin at the point C. These in turn are suspended from the healds. Above the healds are two other pairs of levers D, the opposite ends of which are attached to each separate heald, the two pairs being used for the purpose of ensuring steadiness of working; jerking or

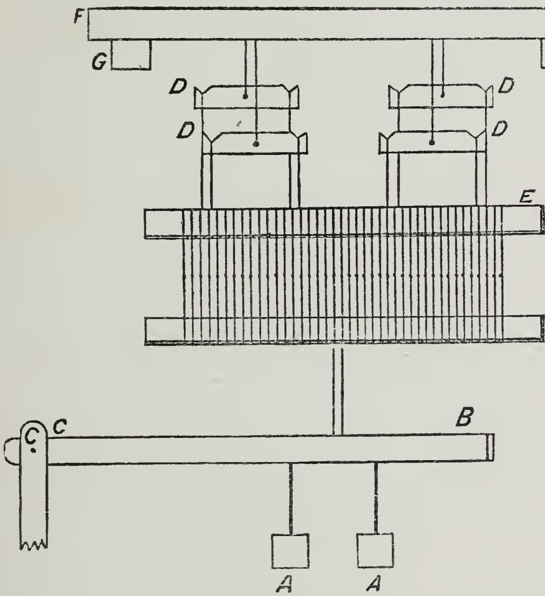


Fig. 5.

unsteadiness being detrimental to the warp, causing the breakage of a good many ends. It will thus be readily seen that as each treadle is depressed alternately the one heald rises and the other lowers, and *vice versa.* By this arrangement of gearing of course only plain cloth could be woven, as the warp threads are drawn through the two healds alternately, therefore each succeeding pick of weft is interwoven with alternate warp threads; but by an

arrangement shown at Fig. 6 a great variety of patterns could be woven; and this arrangement has existed and continued up to the present time, though not always in the exact form shown here; sometimes the long cords passing up the sides of the loom, and connecting the long levers below the healds with the short levers above the healds, being replaced by others passing down through the middle

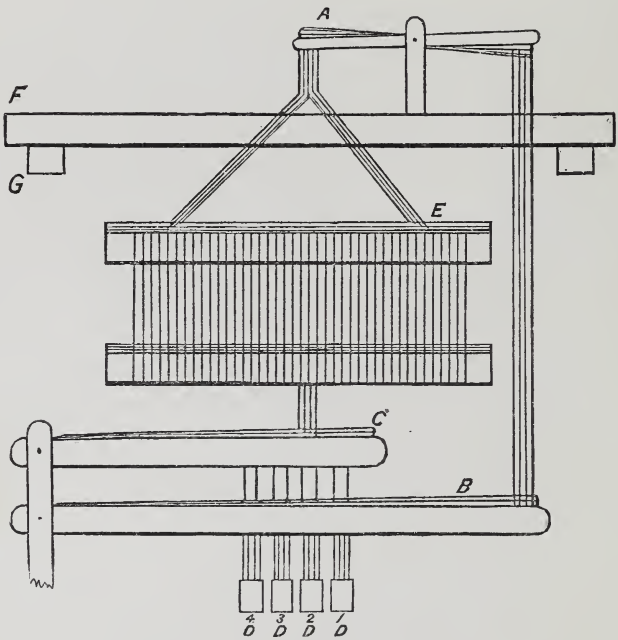


Fig. 6.

of the warp; in that case a double set of short levers are required above the healds, with cords passing from the outer ends, instead of as shown in this drawing. The *modus operandi* of this method of gearing is as follows:—Each heald is suspended from one end of one of the short levers A above, the other end of which is attached to the end of the long levers B; from the bottom of the heald is suspended another lever C, not quite so long as the lever B;

below these again are placed the treadles D. Suppose by treadle No. 1 you wish to raise the first and second healds and to depress the third and fourth (assuming that there are four), attach a cord to each of the first and second long levers B, and one to each of the third and fourth levers C. It will be obvious when that treadle is pressed down the cords acting upon the long levers B will act upon the levers A, and so raise the corresponding healds, while the other cords acting upon the levers C will depress the healds to which they are attached. The treadles must be tied up to correspond with the pattern intended to be woven, and by this means a very great variety of patterns could be produced. Another method of mounting the healds is by substituting pulleys for the levers above the healds.

In the preceding methods it will be observed that every shed—that is every pick in the pattern—which is different from the rest must have a separate treadle, though the same shed may be many times repeated in the course of a pattern; yet it must be obvious that the patterns must be comparatively limited in extent, on account of the number of treadles, so as to keep them within a limit which the weaver could comfortably work. To extend the limits of the patterns various machines have been invented, the culminating point being reached in the Jacquard machine.

Before the invention of machines for opening the sheds, the place of a great part of the treadles was supplied by what was known as the draw boy. To each of the healds that were to be raised was attached a cord, either by means of a lever or pulley, similar to the arrangement for treadles. All these cords were connected to another cord which descended at the side of the loom, and passed through a hole in a horizontal board, which regulated their distances. To the bottom of each cord was appended a

weight to keep it straight, and sink it into its position after being used. Each shed of the pattern had its side cord, as in the treadle loom each shed had its treadle, and the whole were arranged in a straight line in the hole board, in the order in which they occurred in the pattern; the draw boy had thus only to draw the cords in the order of succession to produce the pattern required.

The description given will perhaps lead the reader to a readier conception of the principles of the machine required for this purpose, and to more easily understand the working of such machine, and why it should be required.

Without attempting to describe all the various inventions which have been introduced for accomplishing this work, such as the Draw machine, the Parrot machine, the Dobby, and numerous others, elaborate descriptions of which may be of some historical but not of much practical value, I will attempt to describe the simplest form as used at the present day. I do not intend to go over all the various kinds of machines that are used, nor attempt to enumerate all the improvements that have been made; to do so would be to extend the limits of the present work far beyond what it is my intention it should go. I shall content myself with describing as briefly and succinctly as I possibly can the principles of the machine, and leave the reader to make himself acquainted with the details of construction adopted by different makers of the various kinds of machines, and to form his own opinion of their respective merits, in the only place where such information can be acquired, and such opinions formed, if either the one or the other are to be of any practical value, viz., in the workshop or the mill. The machine which came into most universal use with hand-loom weavers for producing patterns which were too intricate or extensive to be woven upon treadles, approaches very nearly in prin-

ciple the Jacquard machine. In place of the levers which are shown in Figs. 5 and 6, above the healds a machine was substituted, containing a number of hooks. To each of these hooks a heald was suspended, the hooks being so arranged that they could be raised at will by means of a lever passing through the machine, and connected with a long treadle. For the purpose of regulating the pattern, cards or lags are used, these cards or lags being perforated or pegged as the case may be, according to the pattern, so as to strike back any hook connected with the heald which it is desired to leave down, the rest being caught by the lever, and raised up so as to form the shed.

It will be seen at a glance that there is no limit to the number of cards or lags that may be used, and as each card or lag represents a pick of the pattern, the same as the treadle of the treadle loom, or the side cord of the draw loom, the advantages of this loom over both the other descriptions must be obvious.

Though unlimited in the number of lags that may be used, there is a limit to the number of healds that may be used, although before the invention of the Jacquard the number of healds that were employed in one of these machines was enormous, as many as ninty-six having been used at once; and to enable them to put so many in a loom at once, without taking up too much space, or inconveniently crowding, the shafts on which the healds are placed were made extremely thin, and the healds themselves were made of two or three heights, so as not to interfere with each other in working, as shown in Fig. 7. The hooks in the machine were also placed in two rows to economise space.

One great objection to this kind of machine is the weight attached to the bottom of the heald, and this objection is even greater in the power loom than the hand

loom. Yet it is very largely used, or springs, which are if anything still more objectionable, are substituted for them.

This difficulty of the weights may be and is sometimes obviated by using levers under the healds, having two sets of hooks in the machine set opposite to each other, so that when one is struck off the lifting blade the other

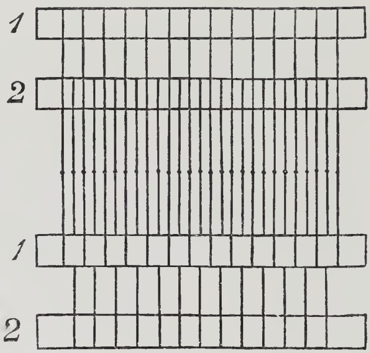


Fig. 7.

is struck on. The heald is suspended from one as in the previous case, and the other is connected with the levers underneath by means of a cord passed down through the warp, so that if the one hook is not lifting the heald, the other is pulling it down; to do this effectually the bottom board of the machine is fixed on movable arms, which give way as the healds are pulled down, and is then brought back to its former position by means of a lever and weight, or any other simple appliance.

Such is the principle of the machine which comes between the treadle loom and the Jacquard, and contains in fact some of the principal features of the Jacquard machine itself, and although for extent of pattern which may be worked it cannot for one moment be compared with the Jacquard, yet it will never be entirely superseded by the

latter machine, as it possesses considerable working advantages, and with skilful manipulation, may be made to produce patterns of great extent and variety.

THE JACQUARD.

The Jacquard machine was the invention of a Frenchman, whose name it bears, a straw hat manufacturer at Lyons. His attention was first directed to the subject of mechanical invention by seeing in a newspaper the offer of a reward for a machine for making nets. He produced the machine but did not claim the reward. The circumstances becoming known to some persons in authority in Paris, Jacquard was sent for, introduced to Napoleon, and was employed in correcting the defects of a loom belonging to the state, on which large sums of money had been expended. Jacquard stated that he could produce the effects intended to be produced by this loom by far simpler means. He was requested to do so; and, improving on a model of Vaucanson, he produced the apparatus that bears his name. He returned to Lyons with a pension of a thousand crowns, but his invention was regarded with so much mistrust and jealousy by the weavers that they attempted to suppress it by violent means. The "Conseil des Prud'hommes," who are appointed to watch over the interest of the Lyonese trade, ordered his machine to be broken up in the public *place*, and, to use the pathetic expression of Jacquard himself, "the iron sold for iron, the wood for wood, and he, its inventor, was delivered over to universal ignominy."

The machine of Jacquard, or at least the machine bearing his name, which is in use at the present day, and which possesses many improvements upon the original machine, is in principle somewhat similar to the one just described. The sheds are opened by means of wire hooks of exactly the same form as those used in the last machine, but these

hooks are more numerous in the Jacquard machine than in the witch machine. Fig. 8 shows a section of a Jacquard

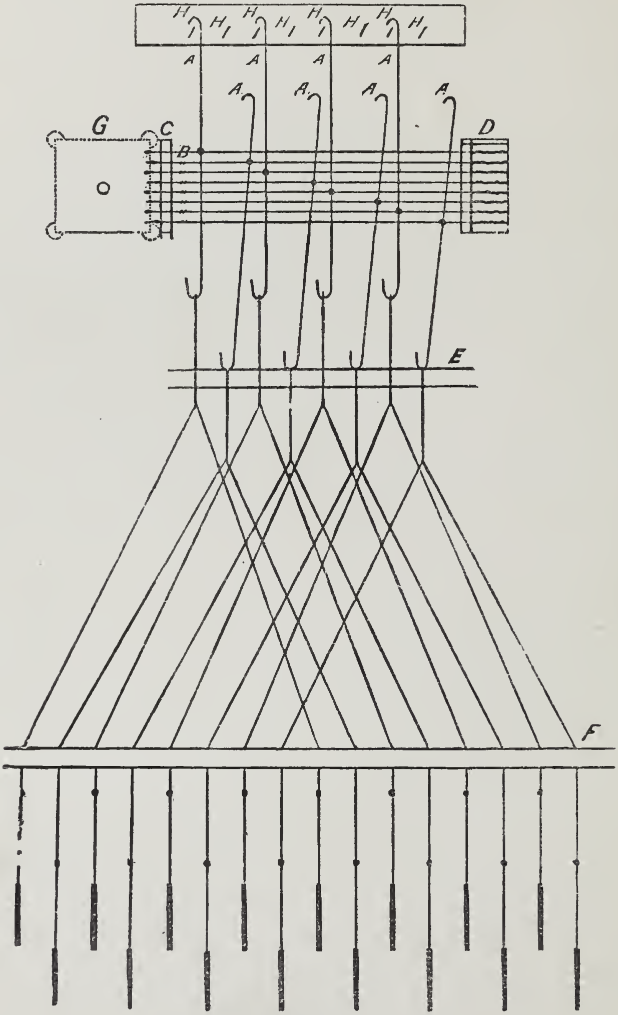


Fig. 8.

machine. The hooks A, A, A, A, A, A, A, A are placed, as will be observed, in eight rows (this varies according to the extent of the machine, the model taken for the present

purpose being what is known in the trade as a 400 machine, that is, the machine contains 400 of these hooks for the purpose of making patterns, and eight which are sometimes used for selvages, or other purposes, as the case may be, thus making a total of 408 hooks in a machine). Each of these is supported or kept in position by a crosswire B, having an eye through which the hook passes. One end of this wire is kept perfectly straight, while on the other end is formed a loop, as shown at Fig. 9; the straight end is

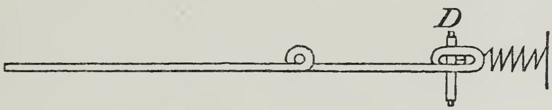


Fig. 9.

passed through a perforated board C, called the needle-board, and is allowed to project about $\frac{3}{8}$ of an inch in front of it; the loop end is secured by a wire pin passed down through it at D. Immediately behind this is placed the spring-box which contains as many small helical springs as there are crosswires, and which are so arranged that each one acts upon the loop at the end of the crosswire. The pressure thus bestowed upon the crosswires keeps them in position through the needle-board C, and at the same time keeps the hooks A in an upright position. To the bottom of the hooks is attached a cord termed the neck-cord; this cord is passed down through the bottom board E of the machine upon which the hooks rest. At a distance of a few feet from the bottom of the machine, and a short distance above the warp line, is placed another perforated board F, known as the cumber board; but this board is very finely perforated, the holes only being large enough to admit of a strong linen thread. These holes are at regular distances, in rows of eight, the distances apart being arranged according to the number of ends

per inch required in the cloth. This board is divided into divisions of as many holes as there are hooks in the machine. Taking the first hook in the machine, a cord is passed down from it and through the first hole in each division of the cumber board. The second hook is treated in like manner, a cord being passed down to every division of the cumber board, and so on, until every one of the four hundred hooks in the machine have as many cords attached to them as there are divisions in the cumber board. Each of these cords has in it what is called a "mail eye," through which the warp passes, and which answers the purpose of the heald; to the bottom of each cord is attached a lead or wire weight for the purpose of bringing it back into its position after being lifted to form a shed. If the reader has followed this description carefully, he will at once observe that, every cord in each division being tied up to separate hooks, each can be worked separate and distinct from the others, and the effect is precisely as if he had four hundred healds in the loom, the divisions being each a repetition of the other. This four hundred, then, represents the limit of the number of ends upon which a pattern can be produced. It will be observed that the position of the Jacquard is such that the row of eight in the machine stands at right angles to the row of eight on the cumber board, so that the harness cords, on being tied to their respective hooks, are bound to cross each other very much. This is what is known as the London tie up. Another way, which is known as the Norwich tie up, is that the Jacquard machine is placed with the rows of eight in the same direction as the short rows of the cumber board. The result of this is that each harness cord is connected with the hook which stands in the most natural relation to it,—thus diminishing the friction among the cords and practically confining the harness within a more limited space.

In the London tie the cards are worked over the side of

the loom. In the Norwich tie they are either over the head of the weaver, or over the warp. Having described in detail the harness, as this corded portion is called, it is necessary now to describe the working of the machine and the method of producing patterns by means of it. It has been shown that the crosswires are allowed to project in front of the needle-board C. From the top of the frame depends an arm, which carries a square perforated bar, or, as it is termed, a cylinder G. In this cylinder the holes are bored to correspond in position with the needle-board, but the holes are larger, so as to allow the needles to enter them the more easily. It will be apparent that if this cylinder be brought in contact with the points of the needles which project through the needle-board, no effect would be produced, simply because each needle would enter a hole, the spring in the box D keeping them in position; but if any of the holes in the cylinder are stopped, it immediately strikes back the needle, the spring giving way under the pressure; the result is that the upright hook is pushed back out of its position over the lifting blades H. These blades are fixed in a movable frame, and their duty is to lift such of the hooks as are not pressed back in the manner described. The way in which the pattern is formed is by having a number of cards cut to the desired pattern and passing over the cylinder. At each tread of the loom the arm is thrown back, and all the needles are liberated. Then, as the shed closes, the cylinder again comes forward with the card upon it, and presses back such of the hooks as are not required to be lifted for the pattern which is being woven. The cylinder is made to revolve by means of catches or pawls, and so change the card at each pick of the loom. To ensure the cards following each other in the proper order of succession, they are fastened together in a continuous chain, by means of string laced through holes which are cut for the purpose at each end and in the middle.

In the diagram I have purposely omitted some of the details (in fact merely showing a skeleton of the machine so as to leave the interior working more clear, and make it more intelligible to the beginner, as it is this part which it is absolutely necessary should be understood, the rest being merely matters of mechanical detail which a glance at the machine would make plain.

The preparation of the cards is an important process in figure weaving, and requires a great amount of care and attention. The first thing that is necessary is that the design should be drawn, on an enlarged scale, upon squared paper, which is intended to represent the warp and weft. This being done, it is taken, and upon a machine which is composed of a number of cords corresponding with the number of hooks in the machine, the pattern is woven as it will be in the cloth. The cords in the machine represent the warp threads, and across these are woven other cords, representing the weft threads. On the opposite side of the machine from that on which the reader sits, each of the warp cords passes through a needle, somewhat similar to the needle or crosswire in the Jacquard. When all the cords are woven in, a roller is substituted for the first cord, and, on being pulled forward, the needles are made to act upon a number of punches which are resting in a plate, and such of the needles as are pulled forward by the cords force corresponding punches out of this plate into another plate, which is then taken and placed on a machine in which a blank card has previously been placed, and the punches are forced through the card, the process being repeated until the pattern is complete. This machine is only used in branches of the business where large and elaborate patterns are made. Very frequently the punches are placed in the plate with the fingers. The cards are made of strong paper, about two and a-half inches wide, and varying in length according to the extent of the machine.

It may not be amiss, before leaving this branch of the subject, to give an example of the manner in which the cards are cut from the design, and to do this the more clearly we will take a plain cloth, as the simplest and most easily understood. The design, Fig. 10, shows a plain cloth working, that is, the black dots represent the weft as passing over the warp thread. To effect this, the threads represented by the white spaces must be raised, and those represented by the black left down for the shuttle to pass over. The design is placed before the card-cutter, between two laths, in such a manner as to leave in view the line which represents the pick of weft he is about to cut the card for. Supposing he is putting the punches in the plate with his fingers, he places a punch in every hole of

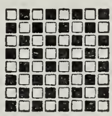


Fig. 10.

the plate corresponding with the white space upon his paper, every eighth line upon his paper being thicker than the rest, so dividing the squares into eights to correspond with the number of holes in a row of his plate. The card and plate are then placed in the stamping machine and the card cut, which will then present the appearance of alternate rows of holes. After one set of cards has been cut from a design, any number may be repeated by means of the repeating machine. In this machine the cards to be repeated are placed on a perforated bar, exactly similar to the one on the Jacquard; through a box in front of this are passed long needles, each having upon it a long helical spring; a plate is bored to correspond with the revolving bar and with the stamping plate; the stamping plate

containing all the punches is placed in front of the plate with the heads of the punches towards it; the holes in the plate are sufficiently large to admit the head of the punch. To obtain an exact copy of the card it is placed on the perforated bar, which is brought forwards by means of a treadle or a lever, generally the former. As the card strikes the needles the holes corresponding with the cylinder on which it is placed admit the needles into the cylinder, thus allowing them to remain stationary, while the portions of the card which are not perforated strike the needles opposite which they come, and force the punches out of the stamping plate into the stationary plate. The stamping plate is then taken and put on the machine, into which a blank card is placed, and the card is punched. The stamping plate is then replaced upon the repeating machine, and a comb, which consists of strong wires placed exactly opposite the holes in the stationary plate, is pushed forward; the wires, entering the holes, push the punches which it contains into the stamping plate, when it is again ready to repeat the next card.

The cards are all numbered in the order in which they are cut from the design, put upon a frame to hold them in proper position in consecutive order, and laced or strung together as previously described.

THE POWER LOOM.

In the preceding chapter I have described the mode of gearing and some of the working parts of the hand loom more fully than might seem necessary, as the hand loom is rapidly going out of use, but my reason for doing this is to make the nature of the operations to be performed as clear as possible before entering upon the mechanical details of the power loom, so that the

student might more readily comprehend the nature of the various movements, without being harassed with too many considerations at once.

The conception of Dr. Cartwright as to the nature of the process of weaving, and of the movements involved in the production of textile fabrics of a plain nature which led him to attempt to make a machine capable of producing and repeating those movements, was strictly correct. Those three movements, which are technically known as shedding, picking, and beating up, are what may be termed the primary movements in weaving. It is true that sundry others must also be performed, but they are all subservient to, and must work in harmony with, these three.

In modern power-loom weaving various means are adopted for producing these various movements, but in all they have the same object in view, and aim at producing precisely the same movement. Consequently, in all classes of looms, the difference consists solely in the means for producing, and not in any degree in the nature of such motions, except in so far as the various degrees of perfection are attained by the several means adopted.

Such being the case, it will be necessary to describe the nature of those movements, and some of the means for producing them, and to endeavour to show in the clearest possible manner the necessity for these movements having a peculiar character imparted to them, but before going into the details of each movement separately, it may be as well to point out what they are and what purpose they serve.

The warp being stretched in the loom, it is necessary that the threads should be separated to allow the shuttle to be passed through from side to side, carrying with it the weft, and so interweaving the warp and weft together. This is what is termed the shedding.

The second motion is the picking or propelling the shuttle from side to side of the loom through the division of the warp, or shed, produced by the first motion.

The third motion consists of beating the weft, which has been passed through the warp, up to the cloth, so that each succeeding pick becomes part of the cloth.

SHEDDING.

We will then commence with the first and perhaps the most important of these movements, viz., the shedding, or in other words, the separating of the warp into two portions to allow of the shuttle which carries the weft passing between them, so as to interweave the weft with the warp. This is the most important of the three movements, not only as to the order of arrangement in which the warp must be divided, for the production of the intended pattern, but also as to the particular manner in which it must be accomplished, for upon the successful or unsuccessful shedding depends in great measure the quality of the cloth produced, as well as the quantity which may be made by one loom. There are various ways in which the quantity and quality may be materially affected by this movement. For instance, over-shedding, that is, opening the shed more than is necessary, or imperfect shedding, which may mean that the shed is not sufficiently opened or that it is not properly equalised, are both very productive of breakages of the warp during the process of weaving, and consequent imperfections in the cloth, as well as materially affecting the appearance of the cloth in other ways.

The question then arises, How is this operation to be performed in such a manner as to arrive as nearly as possible at perfection, and to avoid as far as practicable those faults? I will endeavour to show how this may be

best accomplished; and to do this, I shall illustrate it with heald working, as being the most perfect as well as the simplest form of shedding.

The movement of the healds should be smooth and steady, commencing to move slowly, increasing in speed towards the centre of the stroke, and becoming gradually slower after passing the centre, until they finally merge into a full pause, or rest. If the movement is regular and uniform, that is, maintaining the same rate of speed throughout, the strain upon the warp is too sudden, and considerable breakage must take place, particularly if the warp is of a soft or tender material. The opening and closing of the shed must also be timed in the proper manner to the beating up of the weft to the piece.

The period of opening and closing, and the pause to be given to the healds, must be determined in their relation to the beating up by two considerations, viz., whether the warp threads are required to be spread evenly over the surface of the cloth, or otherwise.

The shed must not be larger than is absolutely necessary for the free passage of the shuttle; indeed, unless the yarn has a good deal of loose fibre projecting from it, which may be liable to choke up the shed and retard the progress of the shuttle, or in the case of very heavy work, it is not necessary that the shed be so far open as to quite clear the shuttle. The small amount of extra friction on the yarn will in most cases be more than compensated for by the diminution of strain. Then, first of all, as to imparting the proper movement to the healds. This movement is generally imparted by what is known variously by the name of tappet and wiper. In the loom there are two shafts which go across its entire width, and which are marked in the perspective view here given, Fig. 11, A and B respectively. The shaft A is called variously the main, crank, or driving shaft, and from this

shaft motion is imparted, directly or indirectly, to all the other parts of the loom. The shaft is provided with two cranks for giving motion to the batten or lay, consequently, at every revolution the weft is beaten up to the cloth. The shaft B is driven from the shaft A by toothed wheels, and carries upon it the tappets for the opening and

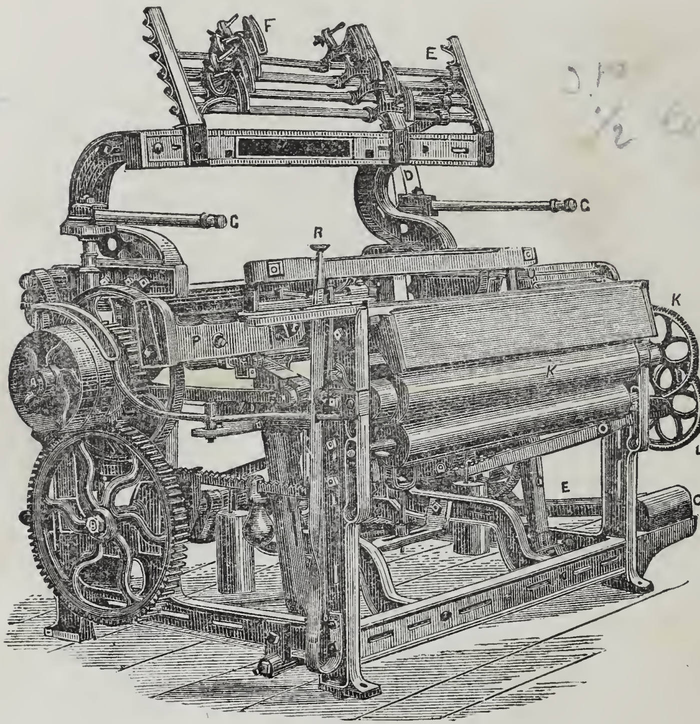


Fig. 11.

closing of the shed, also the picking tappets. The revolutions of the tappet shaft must therefore be regulated in relation to the crank shaft according to the arrangement of the picking tappets, and the shedding tappets must revolve at a speed proportionate to the number of picks in a complete round of the pattern.

We will, first of all, commence with shedding for a plain cloth. The end elevation of a loom, Fig. 12, shows the relative positions of the various parts with which we are at present most concerned. Beneath the tappet shaft B is placed the treadle C (in this case I am supposing the

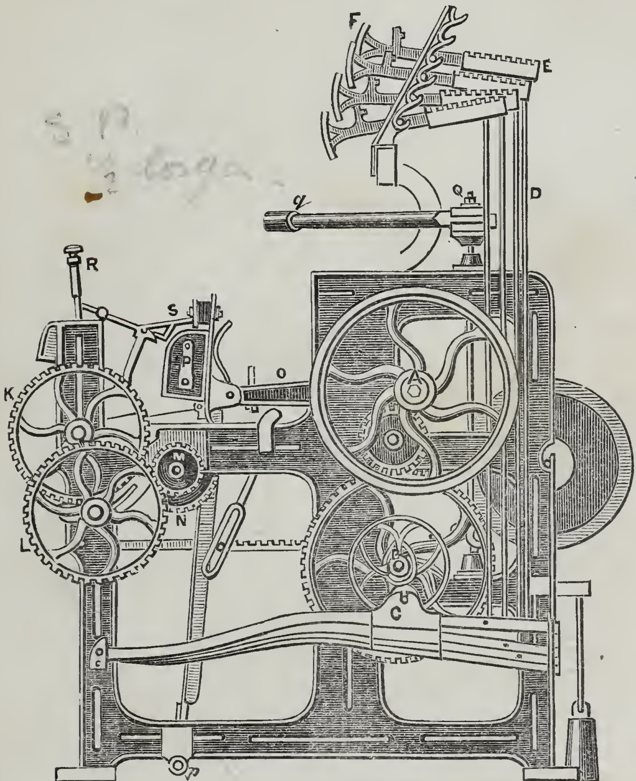


Fig. 12.

shedding motions to be at the side of the loom, as being the most convenient for illustration). From the end of these treadles are connecting rods D to lever arms E, which are fixed upon shafts or rods, working in stands over the top of the healds. Upon each of these shafts are also affixed a pair of arms, F, the ends of which form an arc of

a circle. From these arcs the healds are hung, being connected with each other below by means of pulleys.

In Fig. 13 I have separated this motion from the rest of the loom, so as to show more effectually the connection and working of this part. The treadles C are simply levers working upon the centre *c*, and acted upon by the tappet at a point between that centre and the point of connection

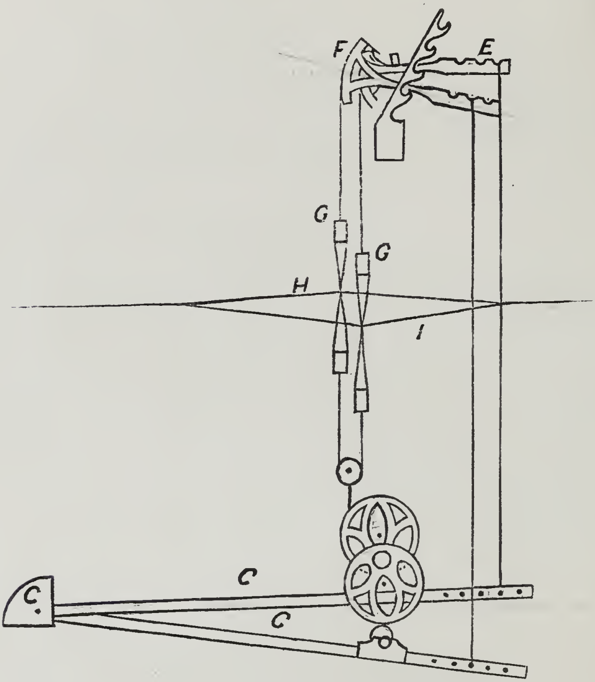


Fig. 13.

with the rod at the other end. This rod simply communicates the motion to the heald G by means of the lever E F, and the connection of the healds with each other at the bottom is so arranged that as one goes up the other is drawn down, and *vice versa*. The lines H I shows the warp separated by the healds.

The arm F of the lever is made to form an arc of a

circle, so that in the act of raising and lowering the heald the latter maintains its proper position throughout, instead of moving to or from the centre upon which the lever works, as it would otherwise do.

The nature and extent of the movement given to the heald, then, must be determined by the form and dimensions of the tappet. We must first of all ascertain the two principal dimensions, that is the distance from the centre of tappet shaft to the point of contact with the friction roller of the treadles, when the latter is in such a position as to allow the heald to be at the lowest point of its stroke, and the length of stroke which must be given to them ; or, to put it in another way, at a certain point of the tappet which is a given distance from the centre of the tappet shaft, the heald rests at its lowest point. We must then determine the dimensions of the tappet to give the required length of stroke to raise the heald to its highest point. In determining this dimension we must take into consideration the leverage of the treadles, as giving so much more of a traverse to the healds.

The treadles are levers of the third order, working upon the fulcrum or centre *c*. The power is applied between the fulcrum and weight. Then, according to a well-known rule in mechanics, as the distance between the power and fulcrum is to the length of lever so is the weight to the power. But as we are dealing with length of stroke rather than with actual weight, we may say, as the distance between power and fulcrum is to length of lever, so is the length of stroke of the motive power to that of the body which receives the power.

Assuming that the total length of the treadle may be thirty inches, and the distance between the point of contact with the tappet and the centre *c* is twenty inches, then as twenty is to thirty so will the stroke of the tappet be to the stroke of the heald.

We will suppose the length of stroke of the tappet is to be three inches, the stroke of the heald, or the distance which it would traverse, would be four and a-half inches. Then assume that the friction roller of the treadle is in contact with the tappet at a distance of three inches from the centre of the tappet shaft when the heald is at its lowest point. With a radius of three inches, describe the

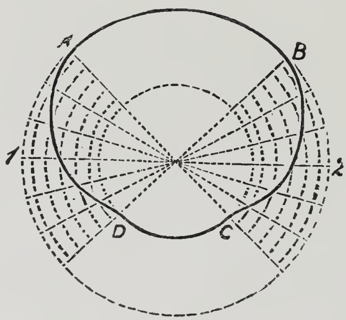


Fig. 14.

circle c, Fig. 14. From the same centre and a radius of six inches (three added to the first radius) describe the outer circle b. This gives us the relative distance of the inner and outer circle of the tappet.

We will first construct a tappet for a plain cloth, which simply consists of the warp and weft interweaving with each other alternately. This tappet must be so constructed that it will raise and lower the heald at alternate picks. That being the case, divide the circles c and b into two equal parts by the diameter 1, 2. The tappet must be affixed to the lower or tappet shaft of the loom, and made to revolve at half the rate of the crank or driving shaft. Suppose the point 1 is the point which would be in contact with the friction roller of the treadle when the crank is at the fore-centre of its stroke, so that the reed is in contact with the cloth, while the crank makes one complete

revolution from that point, the tappet will have traversed the distance 1 to 2, or one-half of its revolution. Assuming that we desire to give a length of pause to the heald at its highest point equal to half a revolution of the crank shaft, and the same length of pause at its lowest point, divide each half of the circle into four equal parts, take the two central parts A B for the pause at the highest point, and the two central parts C D on the opposite side for the pause at the lowest point, then the distance D A must be occupied in raising the heald from the lowest to the highest point, and the distance B C in settling from the highest to the lowest. It is necessary now to draw curved lines from D to A, and from B to C, of such form as will impart the proper motion to the heald. To do this divide the distances D A and B C into any number of equal parts—say six—by radial lines. Divide the distance between the two circles into the same number of unequal parts, commencing with a small division near the inner circle, increasing the size of the divisions as we approach the centre of the space, then decreasing towards the outer circle. Through each of those divisions describe concentric arcs of circles to cut the radial lines. From the point D draw a curved line through each intersection successively until it reaches the outer circle at the point A; from B draw a curved line in the same manner to C, that will give the complete form of tappet. This tappet would act upon one treadle, and consequently upon one heald only. Then we must have another tappet to act upon the second heald. As both the healds must work in the same manner, but alternately with each other, the construction of the second will be the same as the first, but placed with the projection in the opposite direction.

There are one or two matters in connection with the construction of this tappet to which it is necessary attention should be called, and as these matters are of the

highest importance the student cannot observe them too closely. First we take the point 1 as the point of contact with the friction roller of the treadle when the reed is in contact with the cloth. On examination it will be found that the two healds will each have traversed the same distance from the highest and lowest points respectively, that is they would be passing each other in the centre of their stroke, so that by the time the crank has made one-fourth of a revolution they will have reached their highest and lowest point, or opposite extremities of their stroke. They both remain in that position, keeping the shed full open for half a revolution of the crank shaft, or while the lay carrying the reed has traversed the distance from the centre of its stroke to the furthest point from the cloth, and back again to the centre of stroke; the reason for this being to allow time for the shuttle to pass through from side to side of the loom before the shed begins to close, the same process being repeated for the next pick. Secondly, it is necessary that some explanation should be offered of the reason why the distance between the two circles should be unequally divided to obtain the curve of the tappet. It has been pointed out that the movements of the healds must be of an eccentric character; this division is for the purpose of producing that eccentricity. Suppose we take a plane surface and place it in a horizontal position, and place at one end of it a weight, so long as the plane maintains that horizontal position the weight will not move, but if we lower the end which is furthest removed from the weight so as to form an angle, say of thirty degrees, with the horizontal line, the weight will begin to move gradually down it; if the angle is increased to sixty degrees the velocity of the moving body will be considerably increased, and the nearer the angle which the plane forms with the horizon approaches a right angle, the greater will be the velocity of the moving body. The

same thing applies to the tappet, which is a power imparting motion to the treadle. When the friction roller of the treadle is in contact with any portion of the arc of the circle between C and D, the treadle is stationary, because, although the surface of one is acting upon the surface of the other, as it maintains the same distance from the centre upon which it works it continues to be in the same plane. From the point D it begins to descend from that plane, first gradually, then increasing in speed to the centre of the stroke, and from that decreasing till it reaches the lowest point, when it again becomes stationary. The radial lines being at right angles to the circumference of the circle, the nearer the curved line approaches the direction of that radial line, the more rapid is its motion, and the nearer it approaches the direction or the circumference of the circle, the slower is its motion.

One word more respecting the leverage of the treadles. I have pointed out the relative length of the stroke of the tappet and heald, in respect to the leverage of the treadle, but the length of the stroke of the healds may be altered again by means of the lever E F, Fig. 13. The length of stroke pointed out represents the displacement at the point of the treadle, and there would be a corresponding displacement at the end E of the lever; and if the arm F be of a length corresponding to E the displacement or stroke of the heald would be the same; but sometimes the length of the two arms of the lever E F do not correspond, E being frequently made longer than F, therefore in proportion as E is longer than F the displacement of F is reduced, so that this must be taken into consideration along with the leverage of the treadle in determining the stroke of the tappet.

The arm E of the lever is provided with notches so that the rod D may be moved nearer or further from the centre, thus shortening or lengthening the arm. The object of this is not so much to increase or decrease the

size of the shed, but for the purpose of equalising or making all the ends of the upper or lower shed form as nearly as possible the same straight line. If a number of healds are working together the warp threads which are drawn through those furthest from the piece would not form the same straight line with those drawn through the healds nearest the cloth, if all are raised or depressed the same distance, as shown in Fig. 15. Consequently

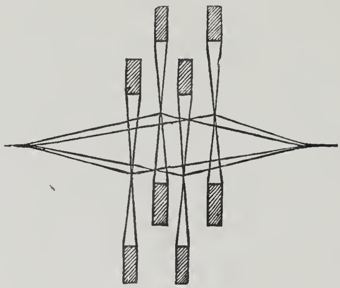


Fig. 15.

those furthest from the cloth must be raised higher or sunk lower than those near the cloth, so as to obtain this straight line, otherwise the shuttle will not run smoothly over them, but will be very materially obstructed in its passage, besides a probability of its passing under some of the threads which it should pass over. The object of the notches in the lever E is therefore to provide a ready means of obtaining this equalisation.

It is sometimes necessary that the length of pause given to the healds be greater than half a revolution of the crank shaft. In the construction of this tappet we have assumed that the reed is in contact with the cloth just at the moment when the healds are passing each other in the centre of their stroke, but in weaving some fabrics it is necessary that the healds should pass each other, so that the shed for the succeeding pick is somewhat open before the pick is actually beaten up. In that case the length of

pause to be given must be somewhat greater, so as to give time for the shuttle to pass through before the shed begins to close, otherwise the shed will be partly closed again before the shuttle gets clear, and would consequently both retard its progress, and in all probability cause breakage of the warp.

To effect this we may give a pause equal to two-thirds of a revolution of the crank shaft, which will give ample time to have the shed partly open before the pick is beaten up.

Then supposing the length of pause which is to be given at each extremity of the stroke is to be one-third of a revolution of the tappet, which will be equal to two-thirds of

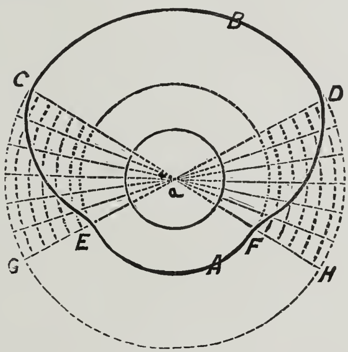


Fig. 16.

a revolution of the crank shaft. From the centre *a*, Fig. 16, describe the two circles A and B; with the radius of the circle B divide the circumference into six equal parts. The arc of the circle C D will be one-third of the circumference (there is a fraction in the matter, but this is sufficiently near for all practical purposes). From the points C D draw lines through the centre, and produce them till they cut the smaller circle at the points E F. The arcs C D and E F give the respective pauses at each extremity of the stroke. Produce the lines C F and D E until they cut the large circle in G H, this will give the distances C G

and D H, each one-sixth of the circumference. Divide the distance C G into any number of equal parts, say six, draw lines from each of those divisions through the centre, and produce them till they cut the arc of the circle D H, thus dividing it also into six equal parts.

Divide the distances C E and F D each into six unequal parts, beginning with a small portion near the inner circle, and getting gradually larger to the third division, and then gradually smaller towards the outer circle, and describe arcs of circles, cutting all the radial lines; connect the points C E and F D with curved lines drawn through the points of intersection of the arcs with the radial lines, and the form of tappet is complete. If this curved line from the inner to the outer circle is carefully followed it will be seen that the required eccentricity is obtained, and it will also be seen that the cause of this eccentricity is the variation of the distances set off by the arcs on the radial lines. Had those distances been equal the curve would have been regular, and consequently the movement of the heald would have been regular. Just as in the last tappet the nearer the curve approaches the radial line the greater will be the momentum of its stroke, and the nearer it approaches the line of the circle the momentum will be proportionately decreased.

If care be not taken this eccentricity of movement may to some extent be neutralised by the position of the treadles. The treadles at the point of contact with the tappet describe an arc of a circle, the curvature of which is in proportion to the distance of the centre upon which the treadle works from the point of contact with the tappet. This distance must, so far as the dimensions of the loom will admit, be such as to reduce the curvature to a minimum, and the point of contact with the tappet must be so arranged that at the centre of the stroke it will be in a perpendicular line with the centre of the tappet shaft.

And the larger the arc described by the treadles at the point of contact the nearer will the position be maintained.

If the point of contact of the treadle with the tappet be either on one side or the other of this perpendicular line from the centre of the tappet shaft, the relative speed of the rising and falling of the treadle will be proportionately affected thereby ; that is, it will rise quicker than it falls, or *vice versa*, according as the centre upon which it moves is placed nearer to or further from the tappet shaft. If the centre upon which the treadle moves is brought nearer the tappet shaft, the tappet will strike it sooner than it should, and if that centre is moved in the opposite direction then it will not strike it so soon ; consequently, the movement which the tappet should give will be more or less neutralised.

Again, the fulcrum or centre upon which the treadle moves should be so placed that the treadle during its stroke moves the same distance on each side of that centre above and below. By doing so the eccentric form of the tappet is slightly assisted, the eccentricity of the movement of the heald being slightly increased. Fig. 17 will show this. A line drawn perpendicularly through the centre of the tappet *a* passes also through the centre of the friction roller *b* of the treadle when in the centre of its stroke, therefore, as the treadle rises above or falls below that point, the centre of the friction roller passes slightly to one side of the perpendicular line ; at the same time the rod D is in a perpendicular position at the centre of the stroke, the treadle being in a horizontal position at the same moment ; consequently, when the treadle is at the highest or the lowest point, the rod D is the same distance removed from the perpendicular position, and the same loss of time in the movement of the heald occurs at each extremity of the stroke. If, on the other hand, the treadle occupied the horizontal position and the rod D the perpendicular position at either extremity of the stroke,

then no loss of time would occur in the movement of the heald at one extremity of its stroke, while a considerable loss would occur at the other extremity when the rod was furthest removed from the perpendicular position, and consequently the eccentric form of the tappet would be somewhat neutralised.

Another matter requiring careful attention also is, that the treadle must be in continuous contact with the tappet, otherwise a jerking movement is imparted, which is seriously detrimental to the warp as well as materially

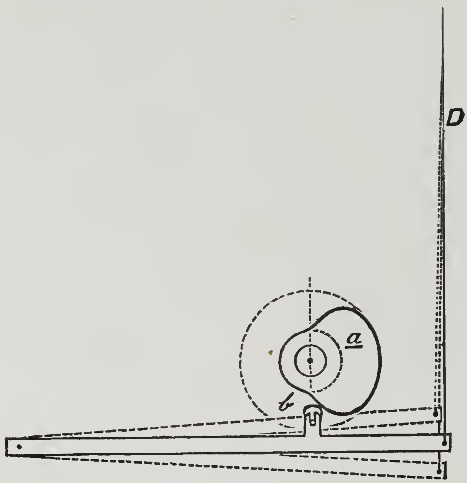


Fig. 17.

interfering with the appearance of the fabric, therefore the tappet must be so formed and of such dimensions that the friction roller is always in contact with it and running smoothly upon it. The question of warp spreading will be more fully dealt with in a subsequent portion of this work.

In this last form of tappet the length of pause given is equal to two-thirds of a revolution of the crank shaft, the tappet making one complete revolution only while the crank shaft makes two; one-third of a revolution of the tappet must be equal to two-thirds of a revolution of the

crank shaft. But it is not general to give this length of pause for every kind of cloth, in fact only in such cases as already pointed out. That being the case it will be well to give a method by which any length of pause can be obtained that may be desired. We will take as an example a four-thread twill, and arrange that the length of pause shall be equal to one-half the revolution of the crank shaft. In a four-thread twill each revolution of the tappet shaft represents four picks, and consequently four revolutions of the crank shaft; that being so, describe the two circles—as in the plain tappet—of the proper dimensions according to the length of stroke to be given; divide

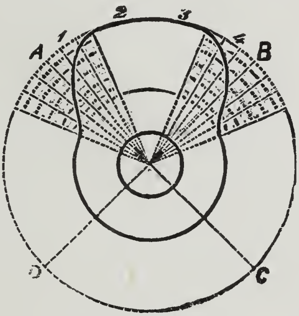


Fig. 18.

the circumference of the two circles by diameters crossing each other at right angles into four equal parts. Each of those parts represents one of the four picks which will be thrown in during one revolution of the tappet. In the example we here take, it is required that each heald rises in turn and remains up for one pick only. If we then divide one of the divisions of the circle into four equal parts, 1, 2, 3, 4, Fig. 18, lay off the two central parts 2 and 3 for the pause, and 1 and 4 are the portions which respectively raise and lower the healds. Taking the point 1 as the point at which the crank commences to revolve for the first pick, for the healds to cross each other in the centre of stroke

we must take one-fourth of the preceding pick to find the point at which to commence rising, and one-fourth of the succeeding pick to find the point at which to cease settling, and proceed just as in the tappet for plain cloth. Each of the four tappets would have exactly the same construction, and be so placed in relation to each other as to raise and depress the healds at the proper time.

The length of pause may be varied to suit the class of work for which the tappet is intended. Thus three-fifths may be taken for the pause, and one-fifth each for the rise and fall.

If, on the other hand, it is desirable that each heald

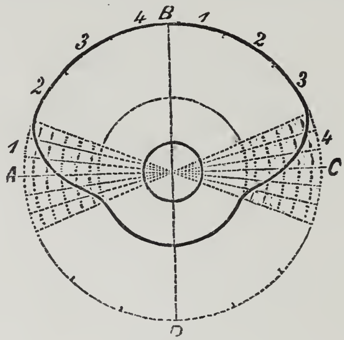


Fig. 19.

shall remain up for more than one pick, as for example in the case of a cashmere or four-end twill, where each heald remains up for two picks and down for two picks, then take two of the divisions and divide them each into four, Fig. 19. take part 1 of one division and part 4 of the second division for the rising and settling portions, and proceed as before.

What has already been said shows accurately the nature of the movement which must be imparted to the healds and, generally, the mode of drawing a tappet which will impart that movement; but it is now necessary to enter more into detail and also to show what other

influence may be at work to neutralise or otherwise affect the particular movement at which we are aiming. So far everything has been given in very general terms, it now remains to give more definite particulars.

In the first place with respect to the construction of the tappet itself. The drawings made, and the modes of drawing, are made upon the assumption that the contact of the tappet with the treadle is at one point, and that point is always the same. Now anyone familiar with the loom knows that upon the treadle is placed a friction roller as shown at Figs. 12, 13 and 17, and that the tappet acts upon the treadle through the medium of this friction roller. If this friction roller be of small dimensions the drawing of the tappets already given will answer all the purposes, because although the tappet drawing is made on the assumption that the rollers is a point, or having no dimensions, a small roller, say one of an inch in diameter, would not materially affect the nature of the movement desired to be imparted. But the moment the friction roller begins to assume larger dimensions it does very materially affect the nature of the movement, and consequently it becomes necessary that the dimensions of the roller should be taken into account.

This is perhaps not a matter of so much importance when there are few picks in the pattern as when there are many, for example, tappets for weaving plain cloth or some of the smaller twills may be drawn without taking the friction roller into account, and would do their work fairly well, whereas for larger patterns, or when there are several projections upon a tappet they could scarcely be made to do their work at all, and certainly not in a satisfactory manner. Though when large friction rollers are used it is better that they should be taken into account at all times, whether there are many or few picks in the pattern.

Suppose we take the tappet given at Fig. 19, for comparison with one drawn with the friction roller taken into account, and for this purpose actual dimensions must be considered. In the drawing referred to, the diameter of the inner circle is six inches—drawn to one-eighth scale—and which is approximately the dimensions of the tappets of this kind commonly used. Now where this tappet is used with a small friction roller, say of not more than one or one and a half inches diameter, the working would be as nearly perfection as possible, but if a friction roller of three and a half or four inches diameter be used it could not be satisfactory, though, to use a common expression, *it would work*.

Suppose we now take one where the diameter of the friction roller is taken into account in the drawing, and let it be of a size commonly used, say three and a half inches diameter, as shown at Fig. 20.

It must be borne in mind here that a diameter of three and a half inches is not by any means a fanciful one. There are thousands of looms at work with rollers of those dimensions at work, and the tendency is rather to increase than diminish the size, therefore it becomes more and more necessary to pay attention to this matter.

Thus, in this drawing, Fig. 20, the radius of the inner circle, and the distance between the inner and the outer circles, or stroke of the tappet, are the same. Suppose a friction roller *a* of the dimensions just given is made to revolve upon the circumference of the inner circle, its centre will describe the line represented by the dotted line A,^{1} and if made to revolve upon the outer circle, its centre will describe the dotted line A.^{2} Then it is now necessary to find the line which that centre must traverse from the circle A^1 to the circle A,^{2} so as to raise or lower the heald, and give it that kind of motion which has already been described. To do that it is only necessary

to proceed according to the instructions already given for drawing, Figs. 14, 16, 18 and 19, but drawing the lines of curvative from the dotted circle A^1 to the dotted circle A^2, instead of from the true inner to the outer circle of the tappet.

By doing this we draw the lines which will be described by the centre of the friction roller, instead of the lines of the tappet itself, and having done that, it becomes quite easy to find the true lines of the tappet.

Having drawn the lines—and which are represented by the dotted lines in Fig. 20—we have a clear indication of the movement of the centre of the friction roller; then taking the

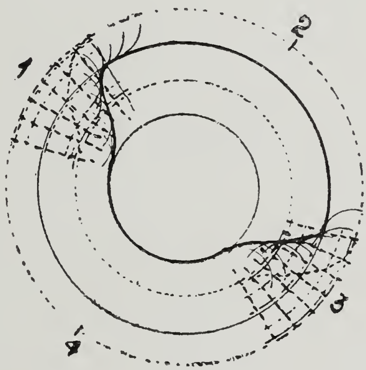


Fig. 20.

radius of the friction roller in the compasses, describe a series of arcs of circles, from any number of points on the curved line already drawn, we find the true line of the tappet from the inner to the outer circle. Or in other words, the tappet is a true tangent to all the arcs of circles so drawn.

It is very evident that a tappet so drawn will give in the best possible manner the movement to the healds which is required, and also that the movement from the highest to the lowest point will be the same as in the opposite direction.

There is one point, however, to which attention must be called. Theoretically one heald will ascend exactly as the other descends, and no doubt that is true after the movement has actually commenced, but at the outer extremity of the tappet there must be a slight loss of time in the movement. If the tappet is constructed strictly to the drawing, the corners of the projections on the tappets will be very acute, and it will be a little difficult for the friction roller to travel over them, they must therefore be very slightly rounded, and this of course occasions a little loss of time in the movement, but the loss is so very slight that it can have no appreciable effect upon the actual work, as any alteration in the tension of the cords and healds together could scarcely exceed one-eighth of an inch over the entire length, and that for only a very brief period of time, consequently it need not be considered at all, seeing that it could have no detrimental effect.

As already mentioned, when the tappets have more than one projection upon them, the question of taking the diameter of the friction roller into account becomes of much more importance.

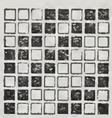


Fig. 21.

For the purpose of further demonstration, a larger pattern may be taken, and the tappet drawn for it by both methods. Let the pattern be that given at Fig. 21. This pattern occupies eight picks, and of course there would be eight tappets required, each of the same form but placed in such position as to follow each other consecutively.

Now this tappet is drawn to the same scale, and in the same proportion as Figs. 19 and 20. The drawing at Fig. 22 is drawn without taking the diameter of the friction roller

into account, and Fig. 23 on the same method as Fig. 20, the diameter of the friction roller being 3½ inches.* It will only require one glance from a practised eye to discover which tappet is best suited for its work.

Let us apply a test to these two drawings for the purpose of seeing clearly where the advantage of one over the other can be found.

We have said that the diameter of the friction roller is 3½ inches, and ostensibly the pause at each extremity of the stroke is equal to half a revolution of the crank shaft of the loom. As has been already shown, this would be strictly so were the point of contact of the tappet with the treadle a *point*, that is, as it is drawn in Fig. 22 the distance between the curved lines which are drawn from one circle to the

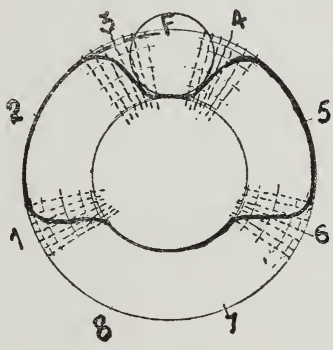


Fig. 22.

other is equal to half a revolution of the crank shaft, and had the friction roller no dimensions that would represent the pause given to the treadle, and consequently to the heald. Now draw the friction roller F in the space between the wings of the tappet, and to the dimensions given, and

* I find on examining the drawing that the friction roller F has been inadvertently drawn 3 inches diameter, though the tappet itself is properly drawn for a 3½ inches roller.

then discover what is the amount of pause actually given. It will be seen at once that this friction roller fills, or nearly fills, the space between the wings or projections of the tappet, so that the moment it has ceased to descend one of the inclines it is compelled to begin to ascend the other, and consequently instead of remaining stationary, and in contact with the inner circle of the tappet only, for a period equal to half a revolution of the crank shaft, it remains there for a very brief period only. On the other hand, if the line which its centre describes be carefully drawn, it will be found that the time lost when in contact with the inner circle of the tappet, is gained when in contact with the outer circle. So that whilst the heald is not allowed to dwell sufficiently long at it lowest point, it dwells far too long at its highest point. As will be shown presently, this possesses serious disadvantages. The exact amount of variation can be readily seen by following the line described by the centre of the friction roller, marking the point where it first reaches its lowest position, and where it begins to ascend from that position, and doing the same thing when at its highest point; then having found these points, finding what proportion it represents of the complete circle of the tappet, or, more readily, of that portion of the tappet which represents one revolution of the crank shaft, or one pick.

A reference to Fig. 23 will now show what the advantages are which will be obtained by drawing on the principle laid down at Fig. 20, for on examination it will be found that the space between the wings of the tappet is such as to allow the friction roller to remain at rest for a period of time exactly equal to half a revolution of the crank shaft.

Attention must now be called to another matter which is of some importance, though not vital, to the drawing of a good tappet. It has been shown that the divisions between the inner and outer circles of the tappet, when obtaining the curve, should be irregular, so as to give an eccentric motion

to the healds. These divisions may be made in any ratio, provided they are the same in relation to the inner as to the

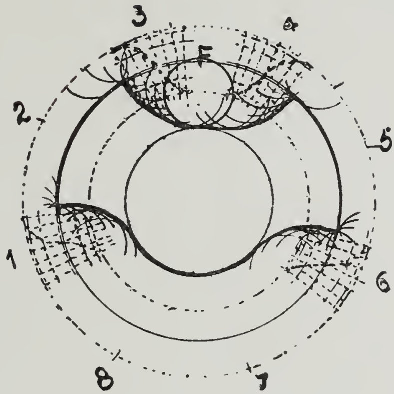


Fig. 23.

outer circle, but the best results are undoubtedly obtained if the divisions are made so as to produce what is termed harmonic motions. For example, take the space, or the distance, between the two circles, and upon a line equal to this distance describe a semi-circle, divide the semi-circle into as many equal parts as you wish to have divisions between the circles, from each of these divisions drop a perpendicular to the base line, and which will divide that line

Fig. 24.

in such a manner as to produce harmonic motion, then those divisions are such as may be used in the construction of the tappet as shown at Fig. 24.

It will be obvious that by this method of drawing, not only will the increase and decrease of velocity communicated to the treadles, and consequently to the heald, be in the best possible ratio, but that as one heald ascends another will descend at exactly the same rate of speed. This is a matter of no small importance in weaving.

In most looms where tappets are employed, the healds are connected to each other by means of cords or straps and levers, or what is equivalent to levers, rollers or bowls, as they are often termed. The necessity for this kind of arrangement is easily understood, the tappet acts in one direction only, that is, it presses the treadle down, but does nothing to bring it back, therefore some means must be adopted to bring it back again, and this must be done either by means of the levers just mentioned or by springs. The use of springs is objectionable on many grounds, although they are often employed with advantage when the tappet is badly constructed, consequently the levers are the best means to be employed when we have good working tappets. The arrangement of these levers then must be such that as one heald is raised, it must, by means of the levers, pull another heald down: this being the case, it is clear that one heald must not begin to ascend before another has liberty to begin its descent, otherwise there will be undue tension upon both the cords connecting the healds and the healds themselves. On the other hand, if the descent of one commences before the ascent of another, the cords will become slack. In either case, bad working must be the result, in fact, they should be so adjusted that there is as nearly as possible the same degree of tension throughout, and it is very evident that this cannot be obtained unless the tappet be carefully constructed.

One other point may be mentioned, viz., that it will very much conduce to accuracy in drawing the curve of the tappet if a large number of divisions be made.

There is but one other matter connected with the tappet

itself which now requires consideration. If a tappet be drawn upon the principle shown here, with a small inner circle and a large friction roller, the former say from five to six inches, and the latter from three to four inches, it will be found that the curve of the tappet will, for some distance, very nearly approach a radial line. Now this renders the working rather difficult, as the incline up which the friction roller travels will be rather steep, and ease in working can only be given to it by altering the position of the friction roller in relation to the centre of the tappet. This is a rather unsatisfactory mode of remedying an evil, therefore it is much better, if the friction roller is large, to make the tappet as large as the space in the loom will permit.

By following this method it becomes quite an easy matter to arrange a set of tappets for any given pattern. After dividing the circumference into as many parts as there are to be picks in each revolution of the tappet shaft, each portion may then be made to raise or lower the heald as desired, and any length of pause given to each thread.

It now becomes necessary to deal in some measure with the means of connecting the healds with each other, so that as one is raised it will supplement the action of the tappet by depressing another, or failing this, to provide some means for bringing about this depression. As has been already said, the best mode of accomplishing this is by means of levers in one form or another, because by their use the non-positive, as it is called, action of the tappets is at once converted into a positive action, or the tappet which can act in one direction only, is made to act in both directions through the medium of these levers.

Suppose in the first instance, that two healds only are employed, if the healds are raised by the action of the tappets, then they may be connected at the bottom by means of any simple lever or roller, so that as one heald is raised, the other, through the medium of this lever or roller is

depressed. In this case there is only one consideration, viz., that the lever or roller, shall be so arranged that the healds are not held too far apart, and if levers instead of rollers be used, the arms shall both be of the same length, so that one shall be depressed just as much as the other is raised.

In arranging these levers—or stocks and bowls, as they are sometimes called—for any even number of healds, there is not much difficulty, the considerations being substantially those which have just been pointed out, first, that they shall not spread out the healds too far, nor occupy too much space in the loom, and second that each arm of the lever shall be of the same length. Of course in the case of a large number of healds being employed, it is necessary to arrange a number of rollers upon each end of the lever. Say for example that eight healds are to be used, then an arrangement such as that shown at Fig. 25 may be resorted to where a lever is

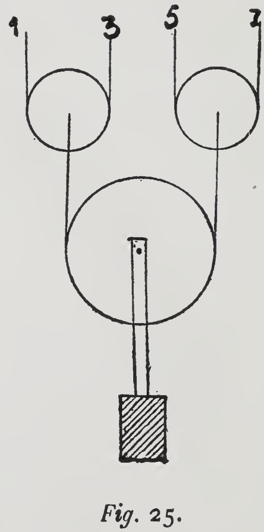


Fig. 25.

shown in section with the necessary rollers attached to it; this lever has its fulcrum in the centre, and the rollers as shown attached to each end, a strap is passed round

the large roller to each end of which is attached a small roller. Again round these are passed straps or cords, and connected directly with the healds. From this arrangement it is obvious that if any one of the four healds be raised, one of them must also be depressed. Suppose for example number 7 be raised it may bring down number 5, but if number 5 is still held up by its own tappet, then through the medium of the roller B, it will communicate with either number 1 or 3, and so depress them. Again at the opposite end of the lever are similar rollers attached to four other healds, so that if none of those at the end where one is being raised are allowed by their respective tappets to descend, then through the medium of the lever, motion is communicated to one of the healds at the other end. This will be more easily understood by reference to Fig. 26, which, as will be presently shown, is an arrangement for seven healds.

It is of course a necessary condition in the use of this kind of arrangement, that as one heald ascends, another must descend, there must always be the same number of healds raised for every pick in the pattern. It does not follow though, that there must always be just half the healds raised, there may be any number, large or small, but whatever that number is it must always remain the same.

It will be noticed that in Fig. 25, the healds 1, 3, 5 and 7, respectively are shown as being attached to the rollers at one end of the lever, this is the most convenient arrangement, as it prevents the rollers from being too small, and gives more room for the cords to work. Of course the other end of the lever would carry the intermediate healds, 2, 4, 6 and 8.

Whenever the number of healds are even, the plan adopted here will hold good, but when they are uneven, a somewhat different arrangement must be adopted, not different in principle, but taking into account the question of leverage. Suppose for example that seven healds are to be

employed, then one end of the lever must carry four healds, and the other end three, as shown at Fig. 26. In this drawing four healds are shown suspended from one end of

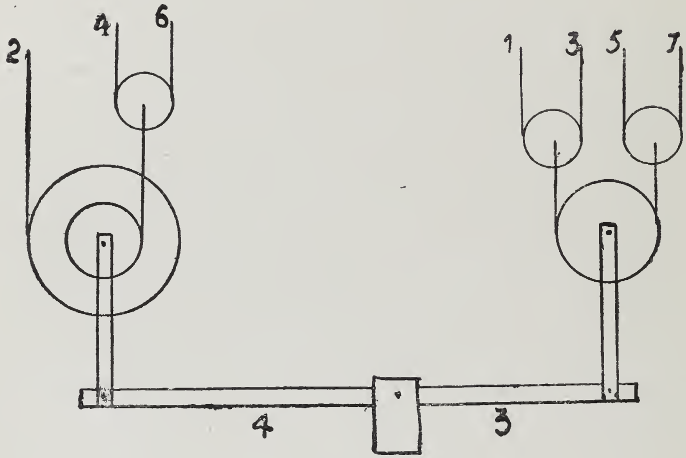


Fig. 26.

the lever, and three from the other. Now it is very clear, that if four pounds weight be suspended from one end of a lever and three pounds from the other, that the opposite arms of the lever must be as three to four in their length; the heavier weight suspended from the shorter arm, and *vice versa*, to enable one to balance the other; exactly the same rule will apply to healds. If there are four healds attached to one end of the lever and three to the other, then the two arms of the lever must be as three to four.

What applies to the long lever applies also to the arrangement of rollers for carrying an odd number of healds as those carrying 2, 4, and 6. Here are two rollers, which by their arrangement constitute a lever, the small roller is made fast to the larger one; to the large roller one of the healds is attached, and to the other is attached another roller, connected with two healds. With this arrangement,

if the heald 2 be raised, either of the healds 4 and 6 will be depressed, but it is evident from the fact that the diameters of the rollers are as two to one, that both could not be depressed by the raising of the heald 2. In fact the diameters of the two rollers being as two to one, and being made fast together, they constitute a lever, the two arms of which bear those proportions to each other.

One difference must be noted in regard to the rollers at one end of the lever in relation to those at the other end, viz., that whilst the straps pass freely round the former, they must be made fast to two of the latter, otherwise they would cease to be a lever.

From the arrangement shown at Fig. 26, it will be readily seen that others can be easily made for any odd number, as that in Fig. 25 shows how they can be made for any even number. For instance, by taking off the rollers from one end of the lever, they will act for four healds If it is desired to provide for three healds only, the rollers from the other end will serve, or a similar arrangement with the rollers of a size suitable to the space to be occupied by the healds. Again it will be easy on the same principle to make an arrangement for five healds, either by attaching three to one end of the lever—as in Fig. 26—and two to the other, and letting the two arms of the lever be as two to three, or by attaching four to one end, as in Fig. 25, and one to the other. and having the two arms of the lever as one to four. Sometimes one arrangement is adopted, and sometimes the other, according to the materials at hand which can be most readily adapted.

It is very evident from this, that levers and rollers can be easily arranged to suit any number of healds, but it must be borne in mind, as already pointed out, that they will only serve for patterns where the same number of healds are raised for each pick, and that in the event of the pattern being irregular in this respect, resort must be had to

springs or weights, or some other means of bringing the healds to their lowest point after being raised.

In constructing a tappet the length of stroke to be given is a matter which must have a due share of attention, so as to regulate the size of shed to suit the size of the shuttle to be employed; and to avoid as far as possible any undue strain on the warp the shed should not be larger than is absolutely necessary to admit of a clear passage of the shuttle from side to side. Then, having found from the size of the shuttle what size of shed will be required, the stroke of tappet is merely a question of leverage.

Suppose one example is given here, it will serve to illustrate the principle of determining the stroke of the tappet, and can be readily adapted to any class of loom. Fig. 27 shows the position of the various parts of the loom which have a bearing upon this question. In this figure, *a*, is the point where cloth is formed, *b*, the lay carrying the reed, *c*, the shuttle, and *d*, the healds. The shuttle is here represented as passing through the shed. For the purpose of making the matter as simple as possible, I will suppose dimensions which will enable the reader to follow the system of calculation easily, these dimensions being such as may be found in existing looms or not, but used merely for the purpose of illustrating the principle. Then we will suppose that what is termed the stroke of the going part is equal to 6 inches—that is, the distance it traverses to and from the cloth is 6 inches—and the width of the shuttle is $1\frac{1}{2}$ inches. So that when the shuttle is passing through the shed, which is when the going part is furthest from the cloth, the front of the shuttle is $4\frac{1}{2}$ inches from the cloth, or $6-1\frac{1}{2}=4\frac{1}{2}$. Then suppose the depth of the shuttle is $1\frac{1}{4}$ inches. Now, as will be seen, the shed is V shaped, and the front of the shuttle being the nearest the cloth, the depth of the shuttle determines the depth of the shed at that point,

so that if the depth of the shuttle is $1\frac{1}{4}$ inches, the shed must be of that depth at a point $4\frac{1}{2}$ inches from the cloth. The question then to determine is, if the shed must be $1\frac{1}{4}$ inches

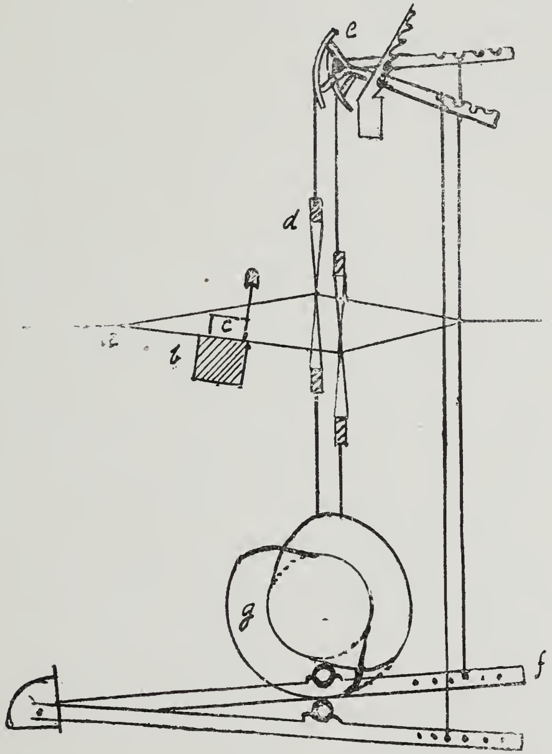


Fig. 27.

deep at a point $4\frac{1}{2}$ inches from the cloth, what depth must it be at the healds ? The question is one of simple proportion, thus, if the healds are say 12 inches from the cloth, then as $4\frac{1}{2} : 12 :: 1\frac{1}{4} : 3\frac{1}{3}$, or the depth of the shed at the healds must be $3\frac{1}{3}$ inches, or in other words, the healds must traverse a distance of $3\frac{1}{3}$ inches from their highest to their lowest point. Then if the healds travel this distance, the

lever *e* from which they are suspended must travel the same distance.

For a moment we may suppose that both the arms of this lever are of the same length, and if that is so, each extremity will travel the same distance, and the point of the treadle F, to which the lever is attached, will also travel the same distance, or the displacement of the treadle at the point where it is connected by the rod to the lever E, will be equal to $3\frac{1}{3}$ inches. Then what we have now to find is, if the displacement at the point of the treadle is $3\frac{1}{3}$ inches, what is it at the point where the tappet acts upon it? This again is a question of simple proportion. Suppose the entire length of the treadle, from the point where it is connected to the lever E, to the fulcrum is 30 inches, and the distance from the centre of friction roller to the fulcrum is 20 inches, then as $30:20::3\frac{1}{3}:2\frac{2}{9}$. Or, the distance which the treadle must travel at that point is equal to $2\frac{2}{9}$ inches, therefore what is termed the stroke of the tappet, or the length of the projection upon it must be equal to $2\frac{2}{9}$ inches, or the distance to be traversed by the treadle at the point where the tappet acts upon it. So that by this means we have an easy mode of determining what the stroke of the tappet should be.

There is only one other point which need be mentioned. The above calculation is made on the supposition that the lever E, has its two arms of equal length, that may be so, or they may be different, but if they are different the difference has only to be taken into account, and dealt with as a proportion, suppose that one arm is 7 inches, and the other 9 inches, and that the healds are suspended from the shorter arm, then as $7:9::3\frac{1}{3}:4\frac{2}{7}$, or the arm which is connected with the treadle must traverse a distance of $4\frac{2}{7}$ inches.

The equalization of the sheds is a matter which cannot have too careful attention. In doing this, care should be

taken not to raise or lower the healds furthest back from the slay more than is requisite, or an unnecessary strain will be thrown on the warp contained in those healds, and consequent breakages will occur. If, on the other hand, they are not sufficiently raised or depressed, the threads will be slack, and consequently will not bear their share of the strain. The lease rods also play a most important part in weaving. Although their primary function, as their name indicates, is to keep the lease of the warp so that when any threads are broken their proper places may be easily found, yet the way in which they are put in, whether plain or otherwise, and the distance at which they are placed from the healds, have a very material effect upon the warp. In some classes of goods—such, for instance, as are made of soft woollen warps—lease rods are not used, but what are known as clasp rods, that is, a pair of rods, one above and the other below the warp, tied together so that the shed shall not open beyond them; and in some cases clasps are used in addition to lease rods.

The action of the tappets, in relation to the movements of the lay, is a matter which, perhaps as much as any other, requires the attention of the weaver; this relative action influencing as much as anything the appearance of the cloth, as well as materially affecting the warp. If it is required that the warp shall be well spread in the cloth, and also in heavy work when a great number of picks are required to be put in, when the pick is beaten up to the cloth the shed for the succeeding pick should be more or less open. If the pick is beaten up before the shed closes upon it it will spring back a little, and the succeeding pick has to drive it forward again.

This crossing the shed, as it is sometimes called, will explain the necessity for the longer pause which the tappet must give to the healds, because the shed opening as the pick is beaten up it must remain open sufficiently long for the succeeding pick to be thrown in.

If the warp does not require to be well spread, then the shed need only remain open sufficiently long for the shuttle to pass through it, the pick being beaten up to the cloth when the healds are even, and before any strain is thrown on the warp by the opening of the succeeding shed. The shed should then open for the shuttle to pass through as the lay moves backwards, when it will, of course, be open widest at the moment when the lay is at its furthest point from the cloth. It will be readily seen that for this kind of shedding the pause must be regulated to suit it.

For tender yarn this method is certainly the best, as it must be obvious that less strain is thrown upon it than by the preceding method. And even where it is necessary that the sheds should be crossed it may be saved considerably by causing the shedding to take place a little later, but the warp will not be so evenly spread, thus detracting from the appearance of the cloth, and as the primary object is, or should be, at all times to produce the best possible effect on the cloth, this latter mode of shedding should only be resorted to when the tenderness of the warp or other considerations make it an absolute necessity, or when the make of the cloth is such that it will be best adapted to it.

SPEED OF TAPPETS.

We must now take into consideration the question of regulating the number of revolutions of the tappet shaft in its relation to the main driving or crank shaft. In the class of loom to which these illustrations more particularly apply the tappets are worked at the side of the loom, but in all classes of looms the same principles are involved, so that the difference is only a matter of detail. Then in this case we have only two shafts in the loom, the crank shaft A, and the tappet shaft B, Fig. 11. The crank shaft as pointed out at page 72, makes one revolution at every

pick of the loom. The lower shaft B carries the picking tappets; these are placed one on each side of the loom, and arranged so as to strike alternately, so that they will propel the shuttle from their respective sides in turn. That being the case, this shaft must of necessity make one revolution while the crank shaft is making two, consequently if the shedding tappets are driven *by* this shaft nothing but plain cloth can be woven, but they may be driven *upon* it, and the number of revolutions be regulated at pleasure. To accomplish this the tappets, instead of being made fast upon the shaft so as to revolve with it, work upon it; in fact, the end of this shaft becomes a stud for them, being kept in place by a movable collar and set screw; the tappets are then driven from the crank shaft by toothed wheels. If convenient it is simplest done by having one large toothed wheel on the tappets, and a smaller one on the crank shaft, then the calculation for the number of revolutions is simply the proportion of the two wheels to each other. The teeth acting alternately on each other their relative speeds will be as the teeth of one are to the teeth of the other. For instance, if it is required to have four picks in the round of the tappets the proportion of the two wheels is as four to one, if for five picks then the proportion is five to one, and so on. Very frequently it may be found inconvenient to have only two wheels. The two shafts are placed at a fixed distance apart; the wheels would therefore have to be of such diameter as to suit this fixed distance; consequently it would frequently happen that in changing from one number of treads to another not only the diameters but the pitch of the teeth would be altered. This it is desirable to avoid as far as possible, and indeed to avoid the necessity of making the wheels of such diameter as to suit the distance of the shafts. This is done by introducing an intermediate wheel, which becomes simply a medium for

communicating the power, without in any way altering the relative speed of the two shafts; therefore the same pitch of teeth may be preserved throughout, and the only thing to observe is the relative number of teeth in the two principal wheels.

In some patterns, where a great number of treads are required in the revolution of the tappet, it may not be convenient to obtain the relative speed by these two wheels. In that case *two* intermediate wheels are introduced, these two being of different sizes. The larger receives its motion from, or is geared into the wheel upon the crank shaft, and carries upon the same stud the smaller wheel which is geared into the wheel connected with the tappets, therefore there are two driving and two driven wheels. Then the driving and driven wheels must stand in the ratio to each other as the speed of the tappets and crank shaft; that is, if the first driving-wheel contains sixteen teeth and the second driving-wheel also contains sixteen teeth, and ten picks are required in the revolution of the tappet, $16 \times 16 \times 10 = 2560$, then the product of the two driven wheels, multiplied by each other, must be 2560, thus, $40 \times 64 = 2560$.

When changing from one number of treads to another, it can sometimes be accomplished by changing one wheel only, which may perhaps be any one of the four. We will suppose that we have to find the number of teeth required in the first driving-wheel, the three other wheels being given, multiply the two driven wheels into each other, $40 \times 64 = 2560$, then multiply the given driving-wheel by the number of picks required in the revolution, $16 \times 10 = 160$, and divide the product of the driven wheels by the product thus obtained, $2560 \div 160 = 16$, the number of teeth, required for the first driving-wheel.

If it is desired to ascertain the number of teeth for the second driving-wheel, the process is precisely the same,

only substituting the first for the second wheel in calculating. Suppose, then, it is desired to find the number of teeth required for either of the driven wheels, the other three being given, then multiply the two driving-wheels into each other and by the number of picks required, and divide by the driven wheel given, thus, $\frac{16 \times 16 \times 10}{40} = 64$. It will be seen by this that it is very easy to ascertain the number of teeth required in any one of the wheels, but care must be taken that there be no remainder in any of these calculations, otherwise one portion of the loom will get in advance of the other with its work, and the result would be anything but gratifying.

Sometimes it may be desirable to ascertain the number of teeth in both the intermediate wheels. In that case the easiest and readiest method is to take the first driving-wheel, and multiply it by the number of picks required in the pattern, and whatever proportion the product bears to the last driven wheel, the two intermediate wheels must bear exactly the same proportion to each other. Suppose in this case we are to have seven picks in the pattern, and the first driving wheel contains 20 teeth, and the last driven wheel contains 120 teeth, it is required to find the two intermediate wheels which will be required, it will be readiest put in the form of a fraction, thus $\frac{20 \times 7}{120} = \frac{140}{120}$ or $\frac{14}{12}$, then the proportion which the two intermediate wheels must bear to each other will be as 14 is to 12. Consequently any multiple of those two numbers, as 42 and 36, or 56 and 48, will answer the purpose.

To prove that it is true, multiply the two drivers together, and the two driven together, and divide the driven by the drivers, thus, $\frac{120 \times 42}{20 \times 36} = 7$, so proving that the wheels are correct. Again, suppose we are to have nine picks in the pattern and the first driver contains sixteen teeth, and the last driven contains 120 teeth,

thus, $\frac{16 \times 9}{120} = \frac{144}{120}$ or $\frac{12}{10}$, consequently any multiple of 12 and 10, as 48 and 40, &c., will serve. And to prove that this is correct, $\frac{120 \times 48}{16 \times 40} = 9$. This will in most cases be found the readiest method of finding the intermediate wheels, and of course may be relied upon for accuracy.

Various methods of driving the tappets are adopted by different makers, but however driven, whether upon a separate shaft or otherwise, or whatever intermediate wheels may be used, the above system will be found to be substantially correct, the details being varied according to the circumstances of the case.

PICKING.

We now come to the second movement in the process of weaving, viz., the throwing in of the weft, or, as it is technically termed, the picking.

This movement differs entirely in its character from the shedding. In picking, a considerable amount of force is required to be exerted at a given moment, for the purpose of propelling the shuttle from one side of the loom to the other; but to ascertain the exact amount of force required to accomplish this work is not one of the easiest matters. The question might very naturally be asked, What creates this difficulty? Have we no means of measuring it? In the first place, we have a certain amount of matter to be propelled through a given space in a given time, which time is almost infinitesimal, the whole movement partaking of the character of a blow. The amount of force required to do that might be ascertained, but it would be difficult to ascertain the amount of resistance offered to it in its passage, which resistance varies considerably under different circumstances. That being the case, nothing but actual experiment can give a positive data. Such experiments must be directed to ascertain the amount of force which would be transmitted by a tappet of a given length

and shape revolving at a given speed, this amount of force being increased or decreased by the leverage of the picking-stick.

But although it is not easy to lay down an absolute rule, yet an approximate result may be arrived at.

We will take for illustration what is known as the cone picking motion, which is the one most generally used, at least in fast-going looms, and it is in this class of loom that strict attention to the picking movement is most required, for if any harshness of movement exists in the loom it is intensified by the high rate of speed, and the effect of it is injurious to the whole loom.

The cone picking motion is an application of a simple lever, and consists of an upright shaft carrying a cone-shaped stud (from which it takes its name) and a wooden arm, known as the picking-stick, and to which is attached the picker. This stud and wooden arm are the two arms of the lever, and the upright shaft is its fulcrum, the amount of leverage being determined by the relative lengths of the stud and arm, the length of the upright shaft being a matter of no importance so far as its action is concerned, the only condition attached to it being that it shall be sufficiently strong to bear the torsional strain to which it will be subjected.

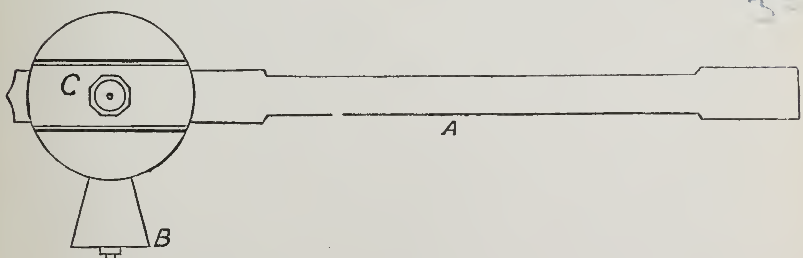


Fig. 28.

Fig. 28 is a plan of this motion, A being the wooden arm and B the cone stud upon which the tappet acts, this

action being of such a nature as to give the requisite amount of force for the work to be accomplished, but the force must be imparted in such a manner as to render the action smoth and easy. Then, to ascertain the nature of this action, we must consider first of all the direction of application of the force and the magnitude of such force.

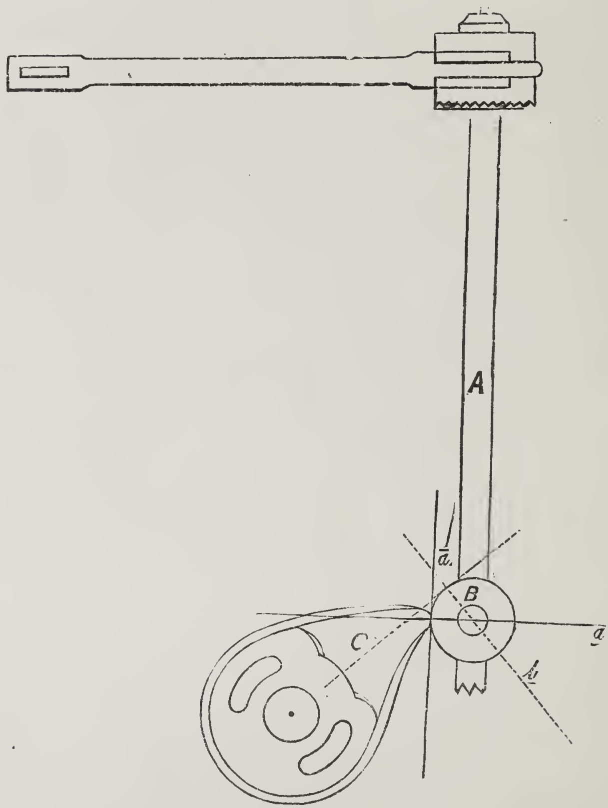


Fig. 29.

First, as to the direction. This is determined by the point of contact of the picking tappet with the cone-shaped stud, or short arm of the lever, which is provided with a

friction roller, upon which the tappet acts. Fig. 29 shows the arrangement, A being the upright shaft, B the cone, and C the picking tappet. The cone being circular, if a line be drawn tangent to the circle at the point of contact with the tappet, as the tappet revolves the direction of force will be at right angles to this tangent, the line *a* will then indicate the direction of the force. Then it must be evident that for the action of the pick to be perfectly smooth the direction of this line should be at right angles (or as nearly as possible) to the vertical shaft A, which is the fulcrum of the lever, and although it is difficult to maintain the magnitude of the force on account of the suddenness of the stroke, and at the same time preserve this line of direction, the nearer the approach to this the more perfect will be the action of the pick. This must be evident almost at a glance. We will suppose for a moment that the point of contact is at *a*; then draw a tangent to the circle at that point, and the dotted line *b* is the direction of force at right angles to it. It requires very little demonstration to prove that a great portion of the force is expended upon the stud, or upon the socket in which the upright shaft works, pushing it downwards, instead of causing the lever to move easily upon its fulcrum; the result is harshness of working, and a certain jerkiness, as well as requiring considerably more force to propel the shuttle, consequent upon the amount of force which is expended upon the stud and socket being lost to the pick.

The direction of force may be regulated by the relative position of the tappet shaft and the cone picking stud, the latter requiring to be placed in such a plane—above or below the plane in which the tappet shaft revolves—as will bring the point of contact in such a position as to give the proper direction to the force. Again, to assist the maintenance of this direction of force the cone and

the tappet must be shaped to each other in such a manner that as the tappet, which is a lever, describes a circle upon its centre, and the lever consisting of the cone and picking stick describes an arc of a circle upon its fulcrum, the contact of the two surfaces will maintain the same position throughout, and that contact shall not be with one portion of the surface—or at one point—but it shall be across the whole surface of the tappet, otherwise an imperfect motion is imparted which cannot be remedied in any other manner.

Another question requiring attention is the position of the upright picking shaft. This may be determined by two considerations, first, the length of picking stick or arm necessary to give the leverage required; second, whether the upright shaft is to be placed in the centre of stroke or otherwise. The first determines the distance at which it must be placed from the lay or going part; the second determines its relative position to the tappet shaft, and consequently the diameter of the disc of the tappet, diameter of cone, and length of tappet nose. Assuming that it is desired to place the upright shaft in the centre of stroke, that is, that the centre of the cone stud shall be parallel to the tappet shaft when it has traversed half the distance from one extreme point to the other of its course, and that the positions of the two shafts have been predetermined by other reasons, then the diameter of the tappet disc and cone must be regulated to suit this position. Suppose the distance between the centres of the two shafts to be six inches, and to obtain the requisite power a tappet nose of three inches is required, then the sum of the radii of the disc and cone added to half the length of the tappet nose must be six inches. Thus, radius of cone $1\frac{1}{4}$ inches, radius of disc of tappet $3\frac{1}{4}$ inches, half length of tappet nose $1\frac{1}{2}$ inches, $1\frac{1}{4} + 3\frac{1}{4} + 1\frac{1}{2} = 6$ inches. But the upright shaft, instead of being

placed in the centre of stroke, may be placed at or near either extremity of the stroke; that is, it may be so placed that the centre of the cone stud will be parallel to the tappet shaft, either before the force commences to be delivered, or when it is finally expended. In the first case, the sum of the radii of disc and cone must equal the distance between the two shafts; in the latter case it will be the sum of the two radii and the length of the tappet nose. In whatever position the shaft may be, the skew form of the tappet must be arranged to suit that position. Having determined the relative position of the two shafts, and the cone and tappet, we now come to the question of the magnitude of force, and the time occupied in its delivery.

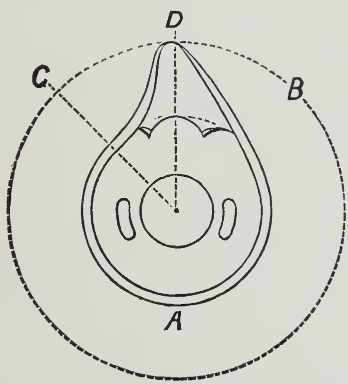


Fig. 30.

First, as to the magnitude of the force required. As I have said, it is difficult to lay down a definite rule, yet we can arrive at an approximate result. In the first place, the intensity of the force depends on the length of the tappet from the circumference of the disc, its form, and the part of the circle occupied by the working face. If we refer to Fig. 30, the circle A is the circumference of the disc, the circle B is the circle in which the tappet moves. If we

draw a radial line through the point where the tappet rises from the disc, and cut the larger circle at C, and another through the point of the tappet at D, the distance C D is that portion of the revolution which the tappet makes while the stroke is being given. This, in conjunction with the leverage given by the picking-stick or arm, gives us an idea of time and space.

We must then take into consideration the question of momentum. In the construction of this tappet a similar principle must be adopted as in the construction of shedding tappets. The first portion of the rise must be gradual, so as to draw up the leather which connects the picking-stick with the picker, and commence to move the shuttle gradually and increase in velocity towards the end of the stroke. This will be increased as the form of the tappet approaches nearer to the radial line.

The question now arises as to the length of the tappet. This must be determined in conjunction with the leverage of the picking-arm, the length of the shuttle-box, and the nature of the stroke to be given. We have assumed the length of the tappet to be three inches from the circumference of the disc, and suppose the leverage given by the relative length of the picking-arm and cone to be as five to one, that would give a length of traverse to the picking-arm which must correspond with the length of the shuttle-box (with an allowance added for length of leather to take the picker back) ; then as the stroke is required to be slow or quick for the work it has to perform, the tappet must be shaped accordingly, that is, the time occupied in the delivery of the stroke must be increased or decreased, and the working face must be made to form a greater or less angle with a radial line drawn from the point of the tappet nose to the centre of the circle. The shorter the tappet the more sudden will its action require to be, and the nearer it must approach the radial line in

form. The slower the required action and the greater the arc of the circle occupied by the working face, and the more gradual the rise from the circle.

There is one matter connected with this class of tappet to which attention should be called. It is no uncommon occurrence for the man in charge of looms, when he wishes to increase the force of the pick, or in other words to give more impetus to the shuttle, to file out the tappet nose, so as to make it resemble a hook in shape, by doing so he apparently gives more force to the final delivery, in reality he makes the movement more sudden, but in doing so he creates bad working, for the tappet instead of acting in such a manner as to preserve the proper direction of force, will, as it were, hook itself upon the cone, and so not only lose its power for a short time, but will act in a very jerky manner.

There is no part of the loom which requires more careful attention than the picking, because from the very nature of the movement there must be considerable re-action in the working parts and accompanied by great wear and tear, and it can only be by a careful observance of the general lines indicated here, along with a proper timing of the pick to the other working parts of the loom (a matter which will be dealt with under the head of general working), that the evil effects can be in any degree mitigated. The easier the movement can be executed the better it will be in every way for the general working of the loom. Too much stress could not be laid upon the necessity of paying strict attention to this part of the loom. No matter what method of picking be adopted, the very nature of the movement makes it difficult to deal with, and it is no exaggeration to say there is more unnecessary wear and tear produced by bad picking, than by a bad arrangement of any part of the loom, and however perfect the loom may be in its other parts, even a slight imperfection in the picking will neutralize it to a considerable extent

BEATING UP OF THE WEFT.

We now come to the consideration of the third of the primary movements in weaving, viz., the beating up of the weft. This is performed by what is termed the lay, which carries the reed dividing the warp threads.

The lay performs two distinct functions, the beating up of the weft and carrying the shuttle. For the first operation a smart stroke of the reed is necessary, and for the latter a somewhat protracted pause, to allow the shuttle time to pass from side to side through the shed formed by the warp. To effect these two purposes it is necessary that the movement of the lay, in its passage to and fro, shall be of a decidedly eccentric character.

Movement is imparted direct from the main driving shaft of the loom to the lay by means of cranks, and it is in the manner in which the continuous circular motion of the crank is converted, as well as in the relative sizes of the crank and crank arm, or connecting rod, that this eccentricity is obtained.

If we take an ordinary crank, and place the connection of the crank arm at its furthest extremity in the same plane as the crank itself, and consider the rod as infinitely long, and let it continue to move in that plane, the motion imparted will be regular in its character, though not moving at the same rate of speed throughout, that is, the regular circular motion of the crank becomes converted into a reciprocating rectilinear motion, a slight pause taking place at each extremity of the stroke of equal duration, and as it approaches those extremities it becomes gradually slower, the highest rate of speed being attained in the centre of the stroke. Take for example the illustration given of harmonic motion at Fig. 24, page 93, there it is shown at what varying rate of speed motion is communicated to any body moving in a horizontal plane

by means of a crank, each division on the circumference of the circle is equal, but the perpendicular lines dropped to the diameter are not equal.

To carry this further, instead of dropping perpendiculars to the diameter, produce the diameter to an indefinite length, and draw a complete circle instead of a semi-circle,

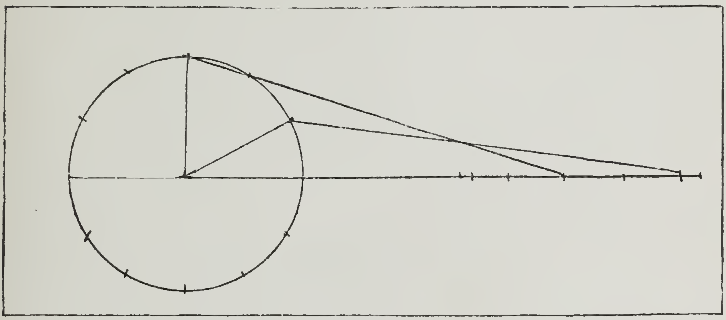


Fig. 31.

having divided the circle into any number of equal parts, take a distance in the compasses equal to the supposed length of the connecting rod, and cut the produced diameter from each division of the circle as a centre, as in Fig. 31. If the connecting rod be of sufficient length, the divisions at each extremity will be equal, but the shorter the rod the greater the inequality, the divisions at one extremity will become less, and those at the other greater, and a decided eccentricity of movement is obtained.

Another mode of showing it is as in Fig. 32, when the point A is the centre upon which the lay moves; the line B shows the position of the sword or arm of the lay when the reed is in contact with the cloth; and the line C is the same arm at the other extremity of its stroke, or when furthest from the cloth: then in its passage the lay describes the arc of a circle, *b c*. It will be observed that when at the fore part of the stroke, the sword or arm occupies a vertical position, consequently, when at the

back extremity the point of connection is brought below the plane which it occupies at the fore part. The circle D is the circle which the crank describes in its revolution, the centre *d* being in the same horizontal line as the point of connection at *b*; then take any two points 1 2, on the arc

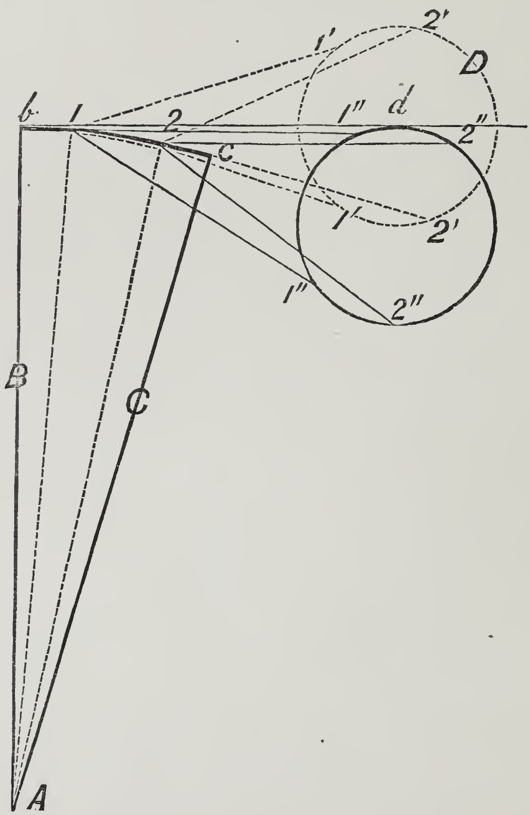


Fig. 32.

b c, at equal distances from *b* and *c*, find the corresponding points in the circle, or the position which the crank will occupy when the lay is at those points; this may be easily done by taking the distance from *b* to where the horizontal line cuts the circle, which will give the length of the crank

arm ; then from 1 cut the circle at the points 1′ 1′ and from 2 cut it at 2′ 2′. On examination it will be found that the arc 2′ 2′ is somewhat larger than the arc 1′ 1′, consequently a longer time is occupied by the lay in passing from 2 to the back extremity of its stroke and returning to 2, than is occupied in passing from 1 to the fore centre and back again to 1.

As the shuttle must be passing through the shed when the lay is at the back part of its stroke, the length of pause which is given here might not be sufficient in ordinary cases to allow it to get clear of the warp before it would be caught by the reed, and as more or less damage would result from its being caught, it may be necessary for this pause to be increased. This may be done by altering the relations between the circle described by the crank itself and the length of the connecting rod, because, as already shown, the shorter the latter in relation to the former the greater the amount of eccentricity obtainable.

The amount of eccentricity thus obtainable will be in direct ratio to the diameter of the circle described and the length of the crank arm. The larger the circle described, and the shorter the crank arm, the greater will be the eccentricity obtained. But there is a limit beyond which this may not be carried, else a hesitancy takes place when the crank is passing the back centre of the stroke, which requires a momentum to carry it over that point, and too great irregularity of movement, or jerkiness, is imparted to the lay.

The broader the loom is the longer the time required for the shuttle to pass through the shed, having a greater distance to traverse, consequently the greater the eccentricity that must be given to the movement of the lay. This may be obtained by increasing the throw of the crank, in proportion to the breadth of the loom. This, of course, also lengthens the stroke of the lay as well, but it

is desirable to limit this to as small a space as possible, so as to avoid as far as practicable the friction upon the warp threads, caused by the reed passing and repassing over them. A very convenient mode of dealing with this matter is to place the crank in a plane lower than that of the point of connection with the going part, as shown by the lower circle in Fig. 32. By this means a large throw of crank can be obtained, and yet the crank be out of the way of the warp, though the point of connection with the sword may be actually on a line with the warp. By having the point of connection as high as possible, a great amount of leverage is of course obtained, and the throw of the crank, or the circle which it describes being increased in proportion to the length of the connecting rod, the requisite amount of eccentricity is obtained. Of course the traverse of the lay, or going part, must be determined to a considerable extent by the size of shuttle, taking for a medium width of loom, say a traverse of three times the breadth of the shuttle; for broad looms a little more, and for narrow ones a little less. But this must not be taken as an absolute rule, sometimes circumstances altering the conditions.

In determining the length of stroke to be given to the lay, the leverage given by the point of connection of the crank-arm with the lay being below the line of contact with the cloth or otherwise, must be taken into consideration. When the rocking-shaft is below, and the connection of the sword with the crank-arm at a point between that and the point of contact with the cloth, the lay becomes a lever of the third order, consequently the same rule will apply as to the treadles, that is, as the distance from the centre of connection to the centre of rocking-shaft is to the distance from the latter centre to the point of contact with the cloth, so will the circle described by the crank be to the stroke of the lay.

Example.—Centre of rocking-shaft to centre of connecting pin 27in.; centre of rocking-shaft to point of contact with cloth, 33in.; diameter of circle described by crank, 5in.; then as $27:33::5:6\frac{1}{9}$, which will be the stroke of the lay.

If the rocking-shaft be placed above and the connection with the crank be placed below the warp line, then leverage will be lost in the same ratio.

It will be observed that the rocking-shaft is so placed here that when the reed is in contact with the cloth the sword is in a vertical position. This is done so that the lay, in its movement, never passes the centre upon which it is working, so as to prevent any vibration which would occur if constantly passing and repassing that centre, and which would interfere in a considerable degree with the working of the loom; and in addition to preventing that vibration, the reed, striking the cloth at right angles, strikes a firmer blow than it otherwise would.

The bevel of the shuttle race is the next matter which calls for attention. When the lay is thrown back for the shuttle to pass through, the race should be bevelled to suit the shed, that is, it should form a similar angle to a horizontal line that the lower half of the shed forms, but the reed and the back of the boxes must form a line directly parallel with the swords upon which the lay works. The effect of this is that the shuttle runs as it were in a dovetailed groove, and consequently runs much steadier and is not so liable to fly out; and the bevel being suited to the shed the warp offers less resistance to the passage of the shuttle, thus producing smoother working and reducing the friction of the shuttle upon the warp to a minimum.

The actual bevel of the race, or more correctly speaking the angle which it forms with the reed, will, in the case of the rocking-shaft being below, be determined by the position of the rocking-shaft in relation to the point of contact with the cloth, and in a slight degree by the length

of stroke given to the lay. If we take a given bevel, with the rocking-shaft in a line perpendicular with the point of contact of the reed with the cloth, or at least with the swords of the lay in a perpendicular position when the reed is in contact with the cloth, this bevel will require to be increased as the rocking-shaft, or centre upon which the lay works, is moved towards the centre of motion, because the nearer the centre upon which it works is to the centre of motion the less is the reed thrown out of the perpendicular, and consequently the less angle formed by the shuttle-race with the horizontal line when the lay is at the back extremity of its stroke; the bevel of the race must therefore be increased to compensate for this loss of angle. When the lay is worked from above the length of stroke decreases the bevel of the race in the same ratio as it is increased when worked from below.

THE TAKE-UP MOTION.

We now come to the consideration of what may be termed the auxiliary motions of the power-loom, motions which are highly valuable in themselves, and without which a power loom would be of little practical use, yet at the same time these motions can only be considered as adjuncts to the three motions already considered, and as assisting them in their operations.

The first, and perhaps the most important of these, is the take-up motion, the object of which is to wind the cloth on a beam as it is woven, and by regulating the speed at which it so winds the cloth, determining the closeness of the weft threads, as the warp threads are determined by the closeness or fineness of the reed.

There are two descriptions of taking-up motions, which are known respectively as the drag and positive. The first, as its name implies, being a dragging motion, the cloth

beam being weighted by a lever and weights, the amount of weight used being regulated to suit the strength of fabric required to be produced, and during the process of weaving, as the diameter of the cloth beam increases by the winding on of the cloth, the weight must be decreased to compensate for it.

The positive motion is of a totally distinct character, the cloth beam being driven by a feed roller acting on the cloth as it winds round it; by this means it is not affected by the diameter of the cloth beam, the movement being regular throughout, consequently it may be driven by a train of wheels, one of which may be movable, so as to determine the rate of take-up or speed at which the cloth is wound on the beam. By this means much more even fabrics may be produced, and with considerably less attention, beyond ascertaining the proper wheel that will be required to give a certain number of picks per inch.

The positive motion is the one now most generally adopted, except for very heavy work, where the teeth or fluting of the feed roller, to be sufficiently effective in carrying down the cloth, would have to be so strong as would probably damage the cloth, or perhaps in such cases as where the yarn is of an uneven character, and it is desired to keep the cloth of as nearly as possible the same thickness.

By the arrangement of the drag, or, as it is sometimes called, the balance motion, the cloth is carried forward a distance equal to the diameter of the weft inserted at each pick, whereas the positive motion carries the cloth forward exactly the same distance at each pick, no matter what may be the diameter of the weft. Such being the case it is evident that the former is well suited for cloths made from yarns which vary in their diameters very greatly, and when, as nearly as possible the same bulk of cloth is required, as in woollen goods, and the latter for evenness of

texture, and cloths made from yarns of an even character, as worsted.

The rule to find the number of teeth in the change pinion to give a certain number of picks per inch may require some explanation. The train of wheels in all classes of looms is not always the same, but the following is the general arrangement. Fig. 33 shows the wheels and their relation to each other; A is the feed roller; B is the feed roller wheel; into this is geared a small pinion C driven on another wheel D; this wheel is driven by the change pinion E, which is in turn driven by the ratchet wheel F, being carried on the same spindle. At every

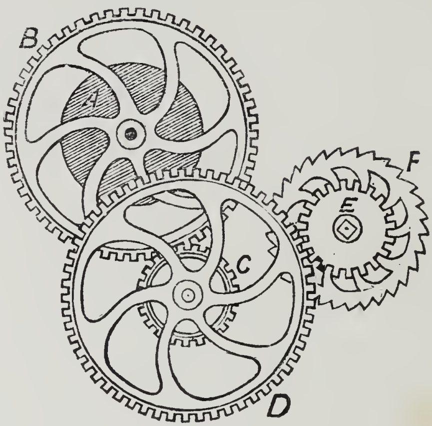


Fig. 33.

stroke of the lay the ratchet wheel is driven forward one tooth by a catch or pawl attached to the sword of the lay, then the question to determine is, having a feed roller of a given circumference, a train of wheels of given dimensions, driven by a ratchet wheel, also of given dimensions, moving one tooth at every pick of the loom, to find the number of picks which will be woven in every inch of cloth with a change pinion of given dimensions; or, what dimensions

of change pinion will be required to weave a given number of picks per inch.

The latter will perhaps be the simplest as well as the most useful way of examining the question, as it is certainly the one most generally adopted.

First of all reduce the first driven wheel, the second driving, and the second driven, or what is termed the feed roller wheel, to one number. The dimensions of these we will suppose to be as follows: the feed roller wheel 125 teeth, driven by a pinion of 19 teeth, carried on a wheel of 125 teeth. If we multiply the two large wheels into each other and divide by the small one we shall arrive at this result, thus $(125 \times 125) \div 19 = 822$. If we multiply this number by the number of teeth contained in the ratchet wheel, and divide by the number of picks required in the circumference of the feed roller, the quotient will be the number of teeth required in the change pinion. Then suppose the feed roller is $14\frac{1}{4}$ inches in circumference, the ratchet wheel contains 60 teeth, and it is desired to have 60 picks per inch in the cloth, then $60 \times 14\frac{1}{4} = 855$ picks in the circumference of the roller. The process will then be as follows:—$(822 \times 60) \div 855 = 57{\cdot}682$, but as decimals cannot be taken into consideration in the number of teeth in a wheel, we must take the full number nearest to that, consequently a pinion with 58 teeth will be required to produce the number of picks required.

Or take another example: suppose the feed roller wheel with 107 teeth, driven by a pinion of 12 teeth, carried on another wheel of 107 teeth, then $(107 \times 107) \div 12 = 954$; a ratchet wheel of 50 teeth, circumference of beam $14\frac{1}{2}$ inches, with 60 picks per inch as before, $(954 \times 50) \div 870 = 55$ (nearly) teeth in change pinion.

Or we may put the matter in a rather shorter manner. Multiply the driven wheels and the ratchet with each other, and divide by the number of picks in the circumference of the beam

multiplied by the pinion which drives the feed roller wheel, thus 855 picks × 19 teeth = 16,245; then 125 × 125 × 60 = 937,500 ÷ 16,245 = 57·682 as above. The whole of this process simply resolves itself into the rule given in a previous page, viz., multiplying drivers and driven respectively into each other, and dividing one by the other and by the picks required; but I have taken this method of explaining so as to make it easy for young students or those not intimately acquainted with calculations.

But it is sometimes an inconvenient process to go through the whole calculation to ascertain the number of teeth required for any number of picks, therefore it is easier to take one number and calculate all others by this standard. For instance, if we were to take one pick per inch as the standard, whatever number of teeth is obtained to produce one pick per inch, divided by any other number of picks required, will give the change pinion which will produce that number. Thus, as 60 : 3461 : : 1 : 57,682, thus proving again that a 58-teeth pinion is required.

Again, a practice prevails of counting the number of picks by means of a piece glass or counting glass, of given dimensions, and it is desired to ascertain the change pinion which will give a certain number of picks in the space represented by this glass. Then, instead of taking the number of picks per inch, we must take the number per glass. Suppose the glass to be $\frac{1}{4}$ inch, to ascertain the wheel which will give a certain number of picks per $\frac{1}{4}$-inch we will adhere again to the same dimensions, viz., $(125 \times 125) \div 19 = 822$, and suppose one pick per $\frac{1}{4}$-inch, and a 60-teeth ratchet wheel, $(822 \times 60) \div 57 = 865$. Then a change wheel having 865 teeth would give one pick per $\frac{1}{4}$-inch, consequently this number divided by any number of picks required per $\frac{1}{4}$-inch, will give the proper change wheel; thus, if it is required to put in 60 picks per inch, which is 15 per $\frac{1}{4}$-inch, then $865 \div 15 = 57·682$.

The matter may, perhaps be further simplified as follows :—the ratchet wheel, the large intermediate, and the beam wheels are all driven, the change and small intermediate wheels are drivers, as well as the beam, therefore leaving aside the change wheels and finding the relation of the drivers and driven to each other, thus $\frac{60 \times 125 \times 125}{19 \times 14\frac{1}{4}} = 3462$. So that if a change wheel could be used containing only one tooth, the loom would weave a cloth with 3462 picks per inch. Or on the other hand, if the wheel could contain 3462 teeth, the cloth would contain one pick per inch. Again if we are working to the $\frac{1}{4}$-inch instead of one inch, we have only to divide 3462 by 4, and we have 865 as given above.

It will be easily understood from the foregoing that whatever the dimensions of the glass, or whatever method may be adopted for measuring the number of picks, it is easy to reduce to a simple number the whole train of wheels, which number may be divided by any number of picks on the given space to ascertain the number of teeth in the wheel required, or if divided by a given number of teeth in the change wheel will show what number of picks such wheel will produce. Another matter connected with this will perhaps require some explanation. It will be evident that the foregoing calculations represent the exact speed at which the cloth is wound on the cloth-roller, consequently the number of picks represented is the number which the cloth would count when tight in the loom. But it is a well-known fact that every material shrinks more or less when set free, so that if it is desired that the represented number of picks is to be the number which the cloth must count when out of the loom, a percentage must be allowed for shrinkage, more or less, according to the class of material used.

THE TENSION OF THE WARP.

The regulating the tension of the warp is a subject which requires some consideration, this really accompanying

the taking-up motion. Although it might appear that the taking-up motion draws off the warp from the beam, yet this is not absolutely the case, for the warp is really drawn off by the shedding and the stroke of the lay.

The appearance of the cloth depends a great deal upon the tension at which the warp is held. As a general rule the warp should be worked nearly as tight as the strength of the yarn will permit. If it is woven too slack the cloth presents a raw, lean appearance, which detracts very much from its value, and which can very seldom be removed by any amount of finishing. On the other hand the warp may be held too tight, in that case causing considerable breakage of the yarn, and giving the cloth a hard, harsh appearance and feeling.

This is a matter which will require some attention as each warp is put in the loom, but it is not a difficult matter after a little practice to discover the proper amount of tension to be given.

Care must be taken that a uniform tension be preserved throughout the breadth of the warp. To secure this it is absolutely necessary that the beam on which the warp is wound, the feed roller, cloth beam, and the rails of the loom over which the warp and cloth pass, must be perfectly parallel with each other, and also that the warp be wound on the beam with an equal or regular tension, otherwise unequal and uneven cloth will be the result.

There are many ways of regulating the amount of tension given to the warp, which it would be quite unnecessary to enumerate, as each particular method has its adherents, the general method and the one which stands the longest test is by means of a stout cord round the ends of the beam, one end of the cord being made fast to the loom and the other attached to a lever, upon which are placed weights sufficient to give the required tension. Considerable ease may be given to the warp by what is commonly termed

the spring weight; this consists of nothing more or less than, instead of making the end of the friction cord fast to the loom, attaching it to a spring or a light weight just sufficient to prevent the weights on the lever from gradually settling to the ground; by this means at every opening of the shed the beam gives off warp, and as the shed closes it springs back again, thus keeping the warp at a regular tension, and there is at no time any undue dragging.

Whatever means are adopted for holding the warp tight the one condition just referred to should never be lost sight of. As will readily be understood, when the shed is open there must be a greater length of yarn between the warp beam and the cloth than when the shed is closed. Usually the weft is beat up to the cloth at the moment when the shed is closed, or when it has just commenced to open for the next pick, so that, if the warp beam is held rigidly, the warp will be at that moment in a greater or less degree slack. Now it is well-known that to produce the best cloth, at any rate in the great majority of fabrics, the warp should be as tight as possible when the weft is being beat up; therefore to preserve the tension the warp beam must be made to oscillate in a greater or less degree, so that as the shed closes it will draw back the warp, and hold it, at least as tightly, or at as great a tension when close as open. The ordinary rope or chain arrangement usually accomplishes this in a sufficient degree, but the spring or balance weight just referred to gives even more elasticity to the movement of the beam.

Some of the arrangements adopted for holding the warp at tension, or as they are termed "letting-off motions," hold the beam perfectly rigid, that is, they give off the warp from the beam at a certain fixed uniform rate, but do not allow any oscillation of the beam. When such is the case some other means must be adopted to compensate for it. This is usually provided for by making the back rail of the loom, over which the warp passes, oscillate instead of

the warp beam. Of course it is a matter of little moment whether the oscillation takes place in one or the other, so long as the warp is kept regularly at the proper tension, not too tight at one moment and too slack at another, but in many fabrics it is preferred to regulate the tension by means of the beam, rather than by the rail, as the warp in that case by means of friction, or a brake, upon the beam, adjusts itself more readily than when it is let off by any positive motion, and there is therefore less irregularity in the tension.

Whichever arrangement may be adopted, and there are plenty of advocates for both systems, provision must be made for equalization of the tension in as great a degree as possible.

THE WARP LINE.

While dealing with the warp, attention may be directed to another matter which is of no mean importance in the production of cloth, that is, the line which the warp forms in passing from the back rail of the loom, through the healds, to the breast beam, as it is termed. To the casual observer it will probably appear that this line should be perfectly straight, and for some kinds of cloth that is the case; but in other goods it is not so. This applies more particularly to plain cloth. If the warp forms a straight line when the healds are all even, as the shed opens both halves of the warp have the same tension, consequently each thread retains its own position in the cloth. The threads being divided by the reed, every division is clearly marked in the cloth. This is sometimes desirable, though more frequently the better the warp threads are spread so as to hide these divisions the value of the cloth is proportionately enhanced. This can be easily accomplished by lowering the warp out of the straight line at the healds; the reason of this is, that when the shed is opened the

whole of the tension of the warp is thrown on the lower half, allowing the upper half to be comparatively slack, and the shed for the succeeding pick opening as the weft is being beat up to the cloth, the slack thread spreads out

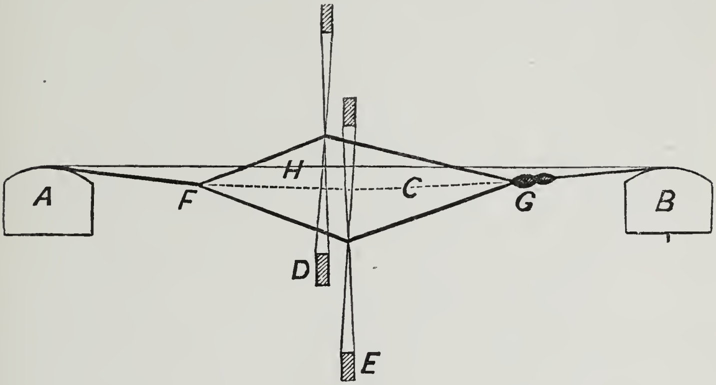


Fig. 34.

between the two which are tight on each side of it. Fig. 34 will perhaps more clearly explain this. A is the breast beam; B is the back rail over which the warp passes; the dotted line C is the line the warp makes when the healds are at rest, which, it will be observed, is not a straight line from the breast beam to the back rail, but is depressed at the healds; D E are the two healds; F is the point at which the cloth forms; and G the lease rods. Then, the healds being at rest and the warp forming the line C, we depress the heald E and raise the heald D each the same distance from the line C, dividing the warp into two portions, forming the lines F D G and F E G. If we then measure these two lines we shall find the line A F E G B is longer than the line A F D G B, consequently that portion of the warp which is represented by the line A F D G B has to bear all the strain and the other half hangs comparatively slack. But it may not be apparent why this is so. Connect the points A B with a straight line H. A straight line is the

shortest distance between two given points, then it must follow that the nearer the line approaches to a straight line the distance must approach the shortest. The line A F D G B is a nearer approach to the straight line H than is the line A F E G B, then the line A F D G B is the shortest, and the more the healds are depressed the greater will be the difference between the two lines. Then it must be obvious that if the lower half of the shed is thus worked at a greater tension than the upper half, the effect must be to force the slack ends into the centre of the space between those which have more strain upon them; and this is assisted by the beating up of the weft, for almost invariably when this arrangement is made the weft is beat up to the cloth after the healds have passed each other, and the shed has begun to open for the succeeding pick; consequently, as the strain is thrown upon each thread alternately, the warp must be spread evenly over the surface of the cloth.

There will be little difficulty in understanding that this arrangement must have a detrimental effect upon the warp in weaving, in consequence of the whole of the strain being thrown upon one half of the warp. Therefore, in weaving tender warps, this expedient can only be resorted to in a limited degree, so that any effort to save the warp in this direction must be detrimental to the appearance of the cloth, and all efforts to improve the appearance of the cloth must in some degree affect the working of the warp. Consideration should therefore at all times be given to the quality of the warp for the class of cloth to be produced.

SHUTTLE PROTECTOR, OR STOP ROD.

This is another contrivance which is of great importance in power looms, its object being the protection of the warp from injury in the event of the shuttle from any cause failing to reach its destination. It requires no great power of imagination to understand that, should the shuttle

happen to be in the shed when the reed beats up to the cloth, the result must be most disastrous to the warp.

What is commonly known as the stop rod is designed to meet this contingency. In the back of the box a spring is affixed which acts upon a lever A, Fig. 35. Attached to the front of the loom frame is a frog, B. The lever is so arranged that when the shuttle is in the box it presses back the spring, and raises the point of the lever—as the lay makes the forward stroke—on the top of the frog. But if the shuttle does not enter the box, the point of the

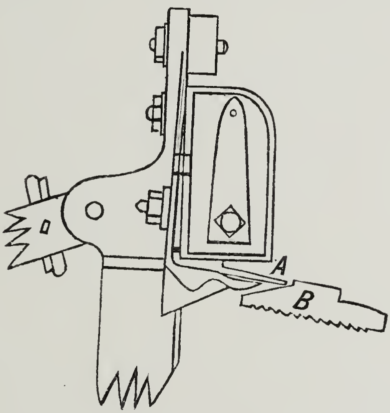


Fig. 35.

lever remains down and strikes the shoulder of the frog; the force of the concussion knocking off the loom, by throwing the belt on the loose pulley.

The action of this protector must be in a high degree injurious to the loom if not properly arranged, for the loom is brought to a sudden stop by the inability of the lay to complete its stroke; the crank shaft is stopped in the centre of its revolution; the other parts of the loom are stopped by the concussion of the wheel teeth, thus causing considerable liability to breakage, in consequence of the momentum which the various parts have gained.

The question then arises how to reduce this liability to injury to a minimum, but before anything can be determined, it must be clearly seen what is the nature of the injury likely to result. It has already been seen that the sudden stoppage of the loom is likely to cause breakage in the various parts of the loom, this may occur either in the teeth of wheels, in the swords of the going part, or in the stop rod itself. But breakage of those parts is not the only trouble likely to arise from a badly arranged stop rod; it may throw considerably more work upon the picking than is necessary, and so not only produce bad working in the loom generally, but very materially increase the wear and tear of all the parts.

In the first place, as to the breakages which are likely to result direct from the action of the stop rod. It is very evident if the teeth of the driving wheels are not sufficiently geared into each other, that is only touching each other at their points, that the concussion which must result from the sudden stoppage of the loom is very likely to cause breakage, because the greater the clearance of the teeth, the greater the force of the concussion.

Liability to breakage of the swords or arms of the lay, may be occasioned by the position of the stop rod in relation to the connecting pin of the swords with the crank arms. If the vertical distance between those two points is too great, a leverage is given which is in direct ratio to the distance between those points, or in other words, the force is applied by the crank at the point of connection with the sword of the lay, and is stopped at the stop rod or protector, then the more the latter is placed below the former, the greater the liability to breakage, because of the increased leverage given to the power as it is applied.

Then as to liability of damage to the stop rod itself, the nearer the frog is placed to the plane in which the stop rod is moving the less the liability to damage to the latter; suppose for a moment that the two are placed in the same

horizontal plane, then the arm of the lever which goes up the back of the box, will be as nearly as possible at right angles to that which strikes the frog, consequently the arm is not so liable to be bent or broken, but all the force is exerted directly upon the fulcrum upon which the lever works, but suppose the frog is placed two or three inches below this fulcrum, then the arm A of the lever will be pointing downwards, and forming an obtuse angle with that which passes up the back of the box, the result is great liability to bending of the arm A, and ultimate breakage; and even if the lever does not actually break, it becomes very soon bent to such a degree, that the shuttle cannot raise it sufficiently high to clear the frog, and as a consequence the loom is constantly being stopped.

Another matter which has considerable influence upon the breakages, and which is very frequently much neglected, is the relieving the loom of the power of the belt as quickly as possible. The frog B is usually made so that it will slide for a short distance on the loom frame when it is struck by the stop rod lever, and it has also a projection from it which is intended to strike the handle communicating with the belt fork, and at the same time liberating the brake. Now too much attention cannot be paid to this part of the mechanism, for the sooner the belt is removed from the fast to the loose pulley, and the brake brought to bear upon the brake wheel, the more quickly is the momentum of the loom reduced, and consequently the less violent the concussion of the various parts. In fact if these parts are carefully adjusted, when a loom is running at a fair speed, the belt is actually on the loose pulley, and the brake in full operation, practically, by the time any concussion takes place in the various parts, so that it is robbed as much as possible of its violence.

Then, next, with respect to the second aspect of the question.—The increased work thrown upon the picking,

The swell, as it is termed, or lever in the back of the box serves a double purpose, it not only enables the shuttle to act upon the lever A B, but it stops the rebound of the shuttle on entering the box. If some provision were not made for this purpose, the shuttle would rebound into the shed, and damage would result to the warp, or the stop motion must be brought into use by some other means. It is obvious therefore that the shuttle has, on entering the box, a certain amount of work to do; it must press back the swell in the box sufficiently to raise the arm A above the frog B, that being so, if the arm B is very heavy, an unnecessary amount of work is thrown upon the shuttle to raise it, therefore it would have to be sent into the box with a very great force, and having reached there, the pressure upon it would be so great that considerable force would be required to send it out again, so that the power required for picking would be increased. Again, the length of the arm A should be just of sufficient length to prevent the reed coming so near the cloth as to cause damage to the warp. If it is too long it has a tendency to catch the frog before the shuttle has had time to raise it clear, and thus stop the loom, or the shuttle must be picked across the loom in a less time than would otherwise be necessary, again throwing more work upon the picking arrangement than should be. Again, the arm A of the lever should be raised just high enough to pass over the frog B, and no more, otherwise more work, or power, is exerted than is necessary.

It only requires a brief examination of the loom, and its mode of working, to see at once the necessity for paying attention to these points. The manner in which the shuttle is picked from side to side of the loom, partakes of the nature of a blow, therefore the moment the blow is delivered, the loom is released from the pressure of the work it has been performing, and a reaction takes place in all the working parts; then it necessarily follows that the greater

the amount of force exerted, the greater the reaction, and this reaction of necessity occurs at a critical moment, just when the shuttle is being propelled, and may be quite sufficient to divert the shuttle from its course, and with more or less disastrous results, cause it to leave the loom; and even if the reaction alone does not do this, it is certain that the more force a shuttle is propelled with, the more liable it is to be diverted by the least obstruction in its passage, so that even the breakage of a warp thread is often sufficient to cause the shuttle to leave the loom, when more force is exercised than necessary to propel it.

The additional wear and tear, not only upon the picking leathers, pickers, shuttles, and all the parts of the loom connected with the picking arrangements, but upon the loom as a whole, are considerations not to be despised, for it is very evident that the exercise of unnecessary force, must

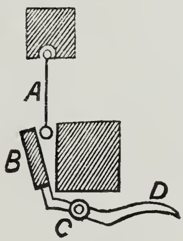


Fig. 36.

enormously increase the wear and tear in the picking arrangements, but the great reactions must in great measure both wear out, and tend to derange all the other parts of the loom.

Another method of affecting the object of the shuttle protector is by means of the loose reed. By this contrivance the lower part of the reed, instead of being held in a groove, is held by a loose board behind it, as shown in Fig. 36, where A is the reed and B the board which keeps it in place. This board is attached to an iron rod, which extends the full width of the lay, working upon the

centre C, and provided with a finger D, so that if the shuttle should stop in the shed the reed is forced back (being only held in position by a spring E, Fig 37), and is consequently liberated. The arrangement is further shown at Fig. 37. If nothing more were provided than this spring it will be obvious that the arrangement would be very unsatisfactory, because if this spring were very strong the warp would suffer before it would give way so as to liberate the reed, and if it were not strong it would be impossible to beat much weft into the cloth without some other arrangement. This contingency is provided for by the presence of the frog F, which is attached to the front of the loom, and so placed

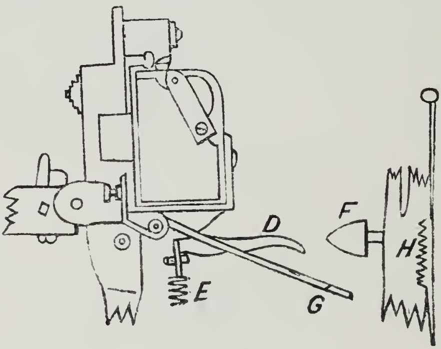


Fig. 37.

that if the shuttle has passed through the shed safely, as the going part or lay comes forward to beat the weft up to the cloth the point of the finger passes under the frog, and so holds the reed firmly in position while the blow is being given. On the other hand, if the shuttle has not passed through the shed, the point of the finger is raised so as to come in contact with the upper part of the frog, which by its form raises the finger and so assists in liberating the reed, and relieving the warp of the strain which would be thrown upon it by the presence of the shuttle; at the same time the arm G, which is attached to the same

rod as the finger, is raised and strikes the front of the handle H, which is connected with the belt fork of the loom, so throwing the belt from the fast to the loose pulley and stopping the loom. Most loose reed looms are now made so that the passage of the finger D up the frog F is dispensed with, and considerable advantage thereby gained, the lever D is produced so as to extend behind the going part, and so make the whole lever something approaching the form of a letter T, the back part of this is provided with a roller which travels, as the lay moves backward, up a bent steel spring. The object of this arrangement is to have the helical spring E as light as possible. When the shuttle is being passed across the loom it presses somewhat on the reed, and in the arrangement shown at Fig. 37, there is nothing but the spring E to keep the reed in position. Now it is obvious that if the warp be a tender one, and the shuttle should be caught in the shed, it would have to raise the point of the lever D somewhat before it could begin to travel up F, and if the spring E is strong enough to keep the reed in position while the shuttle is passing across the shed, it is also strong enough to cause the shuttle to break some of the warp threads; by the extension of the lever, and the use of the steel spring as described, the latter helps to keep the reed in position whilst the shuttle is being passed through, and therefore the strength of the spring E is reduced to a minimum, and should the shuttle remain in the shed, the spring is so light, that, even with a tender warp it will press the reed out of its place without the intervention of the frog F.

The chief objection to the loose reed system is, that it is difficult to make the reed sufficiently firm to give the strength of stroke required for heavy work, consequently it can only be applied to the lighter class of goods.

Recently several new arrangements have been introduced to the trade, by which the reed is perfectly loose until it

reaches a point where the shuttle would be pressing upon it were it in the shed, and would consequently throw it out, after passing that point it is held almost as firmly in its place as in a fast reed loom, in fact it is, as it were, a combination of the fast and loose reed—fast when it is required to beat up the weft, and loose when the shuttle is liable to cause damage, so that the objection to loose reed on account of the want of firmness of the blow is in a great measure removed.

WEFT-STOPPING MOTION.

The weft stopping motion is perhaps one of the most ingenious and delicate, as well as the simplest contrivance of the power loom. In the lay, between the reed and the shuttle-box, is fixed a grate, so arranged as to admit of the three prongs of a fork passing through it at every forward stroke of the lay. On an arm projecting from above the breast beam, and so arranged as to act upon the handle for throwing off the belt, is affixed this fork. The fork is of the form shown at A, Fig. 38, being balanced on the centre A; underneath it is the elbow lever working on the centre B, one end of which rests upon the low shaft of the loom. The top of one arm of this lever is furnished with a catch to correspond with the catch of the fork, the other arm of the lever is acted upon by a cam C upon the lower shaft of the loom, which raises it up, and consequently throws the other arm of the lever back as the lay makes the forward stroke. When the loom is in operation the weft prevents the fork passing through the grate in its natural position by striking the low point of the prongs at *a*, and thereby raising up the hook at the opposite end, thus allowing the arm of the lever in its passage to miss it, but when there is no weft the fork retains its position,

passing through the grate, and is consequently caught by the lever, in this manner acting upon the handle throwing off the belt, and thus stopping the loom.

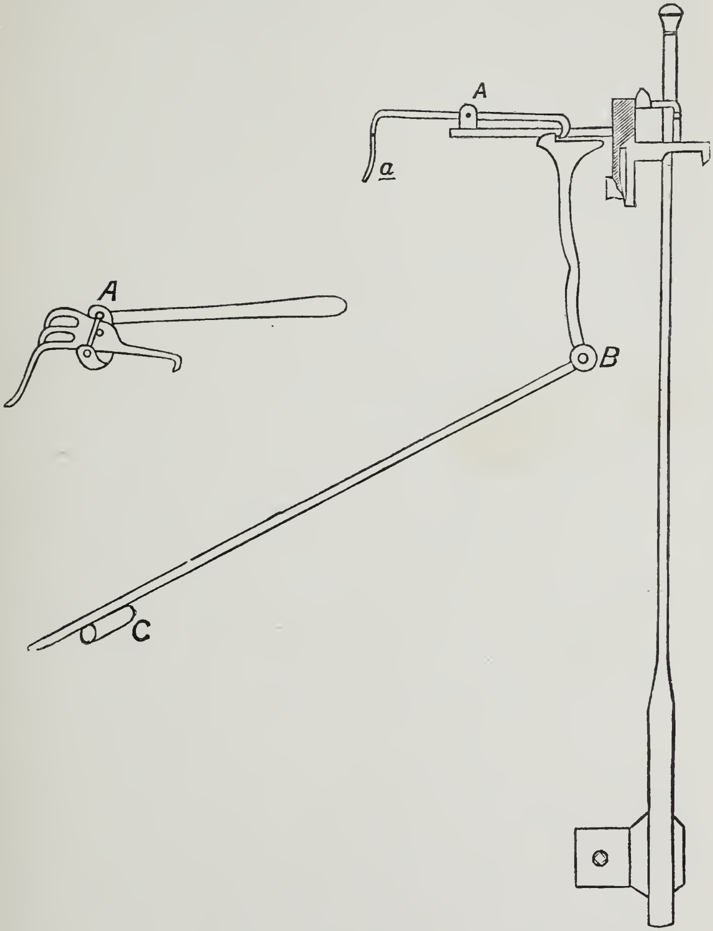


Fig. 38.

This motion is one of simple levers acting in unison with each other, and should this unity of action be in any way impaired, the effectiveness of the motion will not only be destroyed, but a considerable amount of vexation

will be caused by the loom being continually stopped. This shows, then, that the lever must be acted upon at the proper moment, so as to move backward at the moment when the weft should be acting upon the fork. The fork must be properly balanced on its centre so as to keep the hook ready to be acted upon by the catch of the lever, and at the same time not to require more power for the weft to raise it than is absolutely necessary, otherwise when weaving with tender weft the weft will be continually broken by it. The fork must also be in a perfectly straight line with the openings of the grate, so as not to catch the bars instead of passing through.

With due attention to these matters little difficulty will be experienced in the management of this portion of the loom, and it will be found to be a very valuable adjunct to the loom and conduce very materially to the production of a perfect fabric.

GENERAL WORKING OF THE LOOM.

Having gone over in detail the chief working parts of the loom it only remains to examine its general working and the subjects connected with it. The three primary movements—shedding, picking, and beating-up—having been dealt with, we must now look to their relation to each other in regard to time. As I have pointed out before, the beating up is the last of those three in order of execution, yet it is generally most convenient to take it as the base and regulate the others to it, receiving as it does its motion direct from the main driving-shaft, and the others only receiving theirs through other mediums from the same source.

If we place the lay at the fore part of its stroke, that is, with the reed in contact with the cloth, all parts of the loom are at that moment stationary. As the lay begins

to move back from that point the other parts begin to perform their various functions. The first of these is the shedding; the tappets, acting upon the treadles, commence opening the shed, very slowly at first as explained under the head of "tappets," and complete their movement by the time the lay has reached the centre of its stroke, the shed remaining open until it reaches the corresponding point in the return stroke. During this time the shuttle must be passed from one side of the loom to the other, commencing to leave the box at the moment the shed is full open, and reaching the opposite box before it commences to close.

There is no exception to this rule except in so far as the shedding is concerned, as previously explained with respect to spreading the warp, where the shed begins to open before the reed comes in contact with the cloth, and in that case the shed is closed and re-opened more quickly and a larger pause given to the open shed, so as to compensate for the earliness of the movement and still allow time for the shuttle to pass through before the closing commences. These three movements being properly timed to each other it becomes quite an easy matter to regulate the other movements to work in harmony with them. The stop-rod motion, being acted upon by the shuttle, its time of action is of course governed by the shuttle reaching its destination, so that there is nothing more to look to than has been already pointed out. If a loose reed, the finger and frog must be adjusted so as to hold the reed firm at the moment of coming in contact with the cloth, or to assist in liberating it if the shuttle has not reached its proper destination. If the loom be provided with changing boxes, the movement of the box must commence the moment the shuttle has entered it, and complete its movement before the picker moves for the next pick.

The cam which acts upon the weft fork lever should commence its action the moment the reed comes in contact with the cloth, and consequently after the shuttle has entered the box, if there be no weft, the hook upon the fork will be caught by the hammer, and throw off the belt from the fast to the loose pulley, and so stop the loom.

The taking-up motion being worked by the sword of the lay, its time of action remains the same, but care must be taken that the leverage is properly adjusted, so that it moves the ratchet wheel the proper distance at each stroke, otherwise the effect upon the cloth will be far from satisfactory.

These are the chief matters to be attended to in the working of a loom. There are of course a great many other considerations which require their share of attention, but as the majority of them could only be understood by practical demonstration, and the conditions under which they arise are so varied in their nature that it would be tedious to attempt to detail them all here, I shall only refer to a few of them, and they will refer chiefly to the adjustment of the parts. First, with respect to the picking. As the shuttle is propelled from side to side, the force which is given to it is delivered somewhat in the form of a blow from the picker; then this blow must be delivered as nearly as possible in a straight line with the direction the shuttle is to take. To do this the picker spindle must be parallel with the back of the box, otherwise the course of the shuttle, instead of being directed towards the other box, would be sent either with the tip into the slay, or it would leave the loom altogether, in either case with a result which would probably be more or less disastrous. The direction of the course of the shuttle must be assisted by the box also, so that the front and back of the box must be parallel to each other, and the shuttle

must not have too much play or room in the box; at the same time it must not be held too tight, because it would require more force than is necessary to cause it to leave the box, and when it did leave it would do so with a jerk, which must at all times be avoided as far as possible. Again, the shuttle must meet with as little obstruction and resistance as possible in its passage. This implies two things; first, that the reed and the back of the box must form a perfectly straight line; secondly, that the lower half of the shed must lie close down upon the shuttle-race, so that the shuttle can pass easily over it.

If the first of these conditions is not complied with the shuttle will probably fly out of the loom altogether, and if the second be not complied with, the resistance offered to the shuttle would prevent its reaching the box, unless very considerable power were used to propel it, and power should be utilized to the utmost. And even if sufficient power were used to make the shuttle reach its destination, the friction upon the warp caused by it passing over it would be very injurious, causing considerable breakage and consequent imperfections in the cloth. Another fault would also frequently occur, the tip of the shuttle, instead of passing over the warp, would have a tendency to pass under some of the threads, and so cause very serious faults in the cloth.

Too much attention cannot be paid to the adjustment of the sheds, not only so that the warp threads shall touch the race of the lay, but they must not press upon it, and all the healds must be adjusted so that the warp threads all form the same straight line, as pointed out under the head of "shedding," and each successive shed must have the same tension, not have tight and slack sheds alternately.

A variety of other causes than those enumerated may combine to interfere with the working of the loom, but I

have dwelt now upon the chief ones. With careful attention to these, any others which might occur would be very readily detected and remedied. We have now only a few matters to deal with connected with the power loom; these are speed, gearing, &c , and with these I shall deal very briefly. Any one wishing for more information on these subjects will be able to obtain it in works upon engineering, and numbers of such works may be found in any library in the country. So numerous and complete are such works, that I should have omitted this part of the subject altogether, but I felt that a work dealing with the power loom would be incomplete without some reference to it.

SPEED, GEARING, POWER, ETC.

The question of the speed of looms is one which is perhaps as important as any subject connected with the loom. The question, What is the proper speed of a loom? is frequently asked, and receives a great variety of answers. The principle of construction adopted in the parts of the loom, and the work it is intended to perform, alter very materially the conditions of speed. And, again, the nature of the material used in the fabric being woven will have great influence in determining the rate of speed at which the loom should run. Great diversity of opinion exists as to the economy of very-fast going looms, and there is certainly more than one side to the question, and considerations which should receive the most careful attention before an excessive rate of speed is determined upon. These considerations are so varied in their character and occur under such a great variety of circumstances, besides some of them being of a somewhat controversial character, that to enter into them or attempt to enumerate them would not only be a great task, but would be also a most unsatisfactory one. They will be best found in

actual practice, and at the same time will receive a more satisfactory solution. But an invariable rule may be observed with respect to this question. Uniformity and steadiness in working are essential in all machines, but this applies perhaps in a special degree to power looms, consequently, if the rate of speed at which the loom is being run interferes with or affects this in any degree, the result must be proportionately detrimental. With respect to the working parts of the loom and the material being woven, an increased speed means an increased strain, consequently it must be kept within limits which will not be injurious either to the loom or the fabric. In connection with this question of speed we have to consider not only the calculation of speed of machinery in various parts, but also power required for the work to be performed, strength of materials, &c.

It will be as well perhaps to deal first with the calculation of speeds, and then take up the other matters as they arise. The rule which has already been given under the head of calculating speed of tappets is applicable in all cases of toothed wheels. When wheels are applied to communicate motion from one part of machinery to another their teeth act alternately on each other, consequently their relative speed will be to each other as the number of their teeth, and if drums or pulleys are used in the place of wheels the result will be the same, because their circumferences describe equal spaces, or, in other words, are travelling at the same rate of speed, consequently their revolutions will be rendered unequal in the proportion in which their diameters differ.

Then from this is derived the rule, viz.: Multiply the velocity of the driver by the number of teeth it contains, and divide by the velocity of the driven; the quotient will be the number of teeth it should contain. Or in the case of drums and pulleys, multiply the velocity of the driver by

its diameter, and divide by the velocity of the driven; the quotient will be the diameter of the driven.

If the velocities of the driver and the driven are given with the distance of the centres, then the sum of the velocities is to the $\left\{\begin{matrix}\text{velocity of driver}\\ \text{velocity of driven}\end{matrix}\right\}$ as the distance of the centres is to the $\left\{\begin{matrix}\text{radius of driven.}\\ \text{radius of driver.}\end{matrix}\right\}$

Example 1.—If a wheel containing 60 teeth makes 42 revolutions per minute, what number of teeth will be required in another wheel to work in it and make 36 revolutions in the same time? $\frac{60 \times 42}{36} = 70$, the teeth required.

Example 2.—A drum 14 inches diameter, making 80 revolutions per minute, is to give motion to a shaft required to make 112 revolutions in the same time. Find the diameter of the pulley required. Then, $\frac{14 \times 80}{112} = 10$ inches, the diameter of the pulley required.

Example 3.—A shaft revolving at the rate of 60 per minute, is to give motion by a pair of wheels to another shaft at the rate of 24 revolutions per minute; the distance of the shafts from centre to centre is 36 inches. Required the diameter of the wheels at the pitch line.

Then, $60 + 24 : 60 :: 36$ inches : $\frac{60 \times 36}{60 + 24} = 25{\cdot}7$ inches, the radius of the driven wheel, which doubled gives 51·4 inches, the diameter. Then for the second wheel, 36 inches $- 25{\cdot}7 = 10{\cdot}3$ inches, the radius of the driver, which being doubled gives 20·6 inches, the diameter.

These three examples may be varied to suit any circumstances, and embrace all the phases in which the question may present itself.

The question of the pitch of toothed or cog wheels now comes under consideration. What is termed the pitch (or the distance between the centres of two contiguous teeth) is measured on the *pitch-line*, or extreme circumference of the wheel, and the distance between that line and the

centre of the circle is reckoned as the radius of the wheel.

The following rules have been laid down for the diameters and number of teeth for wheels and pinions:

Rule 1.—As the number of teeth in the wheel + 2·25 is to the diameter of the wheel, so is the number of teeth in the pinion + 1·5, to the diameter of the pinion.

Example.—Given the number of teeth in the wheel 96, the diameter of the wheel 24 inches, and the number of teeth in the pinion 16. Then, $96 + 2·25 : 24 :: 16 + 1·5 : 4·27$ inches the diameter of the pinion.

Rule 2.—As the number of teeth in the wheel + 2·25 is to the diameter of the wheel, so is the number of teeth in the pinion + number of teeth in the wheel ÷ 2 to the distance of their centres.

Example—Number of teeth in the wheel 96, diameter of the wheel 24 inches, number of teeth in the pinion 16. Find the distance at which their centres should be placed. As $96 + 2·25 : 24 :: \frac{16 + 96}{2} :: 13·67$ inches, the distance of their centres.

POWER OF TOOTHED WHEELS.

Having now dealt with the question of speeds and diameters of wheels, there is yet one other consideration connected with them, viz., the capabilities of transmitting power by wheels or belts. Upon this subject there is some diversity of opinion. Mr. Thomas Box, in his "Practical Treatise on Mill Gearing," says, "The length of teeth and the proportion of wheels, are matters for judgment, experience, and taste." With respect to the length of teeth, he says, "With iron-and-iron-toothed wheels, the length of tooth above pitch may be $P \times ·344 = l$, and below pitch $(P \times ·344) + (\sqrt{P} \times ·125) = L$. This gives the clearance between the point of the tooth of one wheel and the base of its fellow $= \sqrt{P} \times ·125$, which is equal to $\frac{1}{4}$ inch in a wheel 4 inches pitch," &c. With respect to the thickness of teeth, he says of "iron toothed wheels working together with

rough surfaces, as taken from the foundry, we must allow a certain clearance between tooth and tooth for errors of workmanship and other irregularities. The amount of clearance may be taken at $\sqrt{P} \div 10$, which gives $\frac{1}{10}$th of an inch for one inch pitch and $\frac{2}{10}$ths of an inch for four inch pitch, &c.: hence we have $T = (P - \frac{\sqrt{P}}{10}) \times \cdot 5$, &c.," here T = thickness. With respect to width on the face of the teeth, he gives a rule as follows "$W = P^2 \times 1 \cdot 8 \div \sqrt{P}$," or put in another form $W = \frac{P \times 1 \cdot 8}{\sqrt{P}}$. In these formulæ W = width in inches, and P = pitch in inches.

Sir William Fairbairn in his "Treatise on Mills and Mill Work," gives an example of a wheel of a $2\frac{1}{2}$ inches pitch, and the teeth of which bear the following proportions:

	Proportional parts.
Pitch	1
Depth	0·75
Working Depth	0·70
Clearance	0·05
Thickness	0·45
Width of Space	0·55
Play	0·10
Length beyond pitch line ...	0·35

and from these proportions he gives a very simple mode of constructing a scale which will give the proportions for any pitch.

Unwin in his "Elements of Machine Design," gives the following formulæ, the symbols of which are:—P = Pressure of one wheel on the other. H = Number of horse-power transmitted; b = width of face; p = pitch; N = revolutions per minute; T = number of teeth, then velocity of pitch line in feet per second is $V = \frac{p\,T\,N}{12 \times 60}$

"For the usual proportions, $b = 2\frac{1}{2}\,p$, and iron teeth $p = 0 \cdot 0447 \sqrt{P}$, But $P = \frac{550\,H}{V} = \frac{550\,H \times 12 \times 60}{p\,T\,N}$

inserting this value $p = 28 \cdot 13 \sqrt{\left(\frac{p\,H}{T\,N}\right)}$

or inverting we get the number of teeth of a given pitch necessary for strength, $T = 791 \frac{H}{p^3\,N}$

The same rules will apply to mitre or bevel wheels by taking the average diameter and pitch.

POWER OF LEATHER BELTS.

The following passage occurs in Spon's "Dictionary of Engineering."—"Three rules given by practical mechanics vary so much as to give as bases for estimate (without regard to arc of contact) 0·76 horse-power, 0·93 horse-power, and 1·75 horse-power respectively, for the power of a belt 1 inch wide, running 1000 feet per minute." The same work in considering the results of two series of experiments upon the friction of belts, says, "We see that we are justified in admitting that the ratio of the resistance to pressure is:—

1st.—Independent of the width of the belt, and of the developed length of the arc embraced, or of the diameters of the drums, or what amounts to the same, are independent of the surface of contact.

2nd.—Proportional to the angle subtended by the belt at the surface of the drum.

3rd—Proportional to the logarithm of the ratio of the tension of the stripe, and expressed by the formula

$$\frac{f = \text{Log.}\left(\frac{P}{O}\right)\text{''}}{1{\cdot}363.}$$

Where f is the friction, P the power, and O the resistance.

A table is given also of the power transmitted by belts on pulleys one foot in diameter, one revolution per minute, with the arcs of contact upon the pulleys corresponding to the angles; from which the following is taken:—

Inches width of belt.	90°	120°	180°
	foot lbs.	foot lbs.	foot lbs.
1	102	123	154
5	508	615	770
10	1016	1231	1540

The application of this table is to take the known angle of the arc of contact with the width of belt, and multiply by the diameter of the pulley in feet, and the number of revolutions per minute to find the foot-pounds of power transmitted.

A number of experiments are also recorded upon the tensile strength of belts, from which the following deductions are made as to strength per inch of width—

"When the rupture is through the	lace-holes,	210 lbs.
" " "	rivet "	382 lbs.
" " "	solid part	675 lbs.

The thickness being $\frac{7}{32}$ in $(=\cdot219)$ we have as the tensile strength of the leather 3,086 lbs. per square inch.

From the above we see that 200 lbs. an inch wide is the ultimate resistance to tearing that we can expect from ordinary belts."

Molesworth, in his "Pocket Book of Engineering Formulæ," gives an approximate rule for single belting $\frac{3}{16}$ of an inch thick, as follows:—V = Velocity of belt in feet per minute. H.P. = Horse-power (actual) transmitted by belt, and W, width of belt. $W = \frac{1100 \text{ H.P.}}{V}$

The "Scientific American" in its issue of August 28th, 1880, gives the following formula:— $\frac{W.\ S.}{600} = \text{H.P.}$

In this formula, S = Speed of belt in feet per minute; W = width of belt; and it further says, "with very short or narrow belts, divide by 800 instead of 600. Cooper, in his work on "Belts and Belting," gives some valuable information.

Another rule upon which many work, and which is considered a safe one, is that at a speed of 800 feet per minute each inch width of belt is equal to one-horse power. But such rules as this are very vague, though if made upon a good basis they are very handy.

Unwin, in the work already quoted, gives the following rough calculations of the sizes of belts. In a great many cases in practice, the belt embraces 0·4 of the circumference of the pulley on which it is most liable to slip,—that is, the pulley having the smaller arc of contact—and the co-efficient of friction is at least 0·3. Then $\frac{T_2}{T_1} = 2$.

When this is the case the following simple rules may be used:— "Driving force $= P = \frac{550\,H}{V}$"

$$\left.\begin{array}{lcl} \text{Greatest tension} = T^2 & = & 2P \\ \text{Initial tension} = T^0 & = & 1\tfrac{1}{2}P \\ \text{Width of Belt} = B & = & \frac{2\ \ P}{f} \end{array}\right\}$$

From these rules he has calculated tables of the approximate widths of belts. "The belt being assumed to be $\frac{7}{32}$nds. of an inch in thickness, and carrying safely 70lbs. tension per inch of width," with a velocity of 100 feet per second for

10	horse-power, the	width of	belt is	1 6	inches.
15	,,	,,	,,	2·4	,,
20	,,	,,	,,	3·1	,,
25	,,	,,	,,	3·9	,,

With the velocity at 25 feet per second, the following is the result—

1	horse-power, the	width of	belt is	·63	inches.
2	,,	,,	,,	1·3	,,
5	,,	,,	,,	3·1	,,
10	,,	,,	,,	6·3	,,
20	,,	,,	,,	12·6	,,

It will be seen that although there is some difference in the data given, yet many of them will work out to approximately the same results; and for loom work in particular, from the peculiar nature of the work they have to perform, a safe basis should always be taken. While upon this branch of the subject we may examine

THE STRENGTH OF SHAFTS TO RESIST TORSION.

Fairbairn, in the treatise before quoted, says, "In addition to the lateral strain from transverse forces, shafting is subjected to a wrenching or twisting, from the power transmitted tangentially to its circumference. This causes one end of the shaft to revolve, in relation to the other end, through a smaller or greater angle, known as the angle of torsion; and, if sufficient force be applied, this angle increases till the resistance of the material is overcome, and the shaft gives

way." And after examining the subject in all its bearings he gives "The values of the modulus of wrenching f are

For cast iron about 30,000, for wrought iron about 54,000. And taking six as the factor of safety if we put the working moment of torsion in the formulæ instead of the wrenching moment, we may put instead of f

For cast iron 5,000, for wrought iron 9,000.

Hence we get for W, the working stress, with solid shafts

$$W = \frac{5000\ h^3}{5 \cdot 1 l} = \frac{980 h^3}{l} \text{for cast iron}$$

$$= \frac{9000\ h^3}{5 \cdot 1 l} = \frac{1765 h^3}{l} \text{for wrought iron."}$$

Here h represents the diameter of the shaft, and l the length of the lever in inches.

Mr. Thomas Box, in his "Practical Treatise on Mill Gearing," gives the following rules for the strength of shafts, "irrespective of stiffness."

$$\text{"} H = D^3 \times R \div M$$

$$D = \sqrt[3]{(M \times H \div R)}$$

$$M = D^3 \times R \div H$$

In which H = nominal horse-power, D = diameter in inches, and M = a multiplier derived from experience, and varying with cast or wrought-iron, &c.," and for ordinary shafts he gives the value of M for cast-iron at 254, and for wrought-iron at 160.

Spon's "Dictionary," before quoted, gives "a formula for the wrought-iron shafts of prime movers and other shafts of the same material, subject to the action of gears, which Francis adopted in numerous cases in practice during the last twenty years, and found to give an ample margin of strength.

$$A = \sqrt[3]{\frac{100\ P}{N}}$$

In which P = the horse-power transmitted, N the number of revolutions of the shaft per minute.

For simply transmitting power, the formula used is $A = \sqrt[3]{\frac{50\ P}{N}}$ "

With respect to the bearings of shafts, Mr. Thomas Box says, "The number and position of bearings must be

regulated by the position of the wheels or riggers on the shaft. In all cases the bearings should be as near as possible to the coupling, wheels, &c. But sometimes a long shaft may have no gearing upon it for many feet, and the distance between the bearings must be fixed with reference to the stiffness of the shaft itself. We may admit that a 2 inch shaft, unloaded except by its own weight, may have bearings 10 feet apart, and allowing that the deflections may be in all cases proportional to the distance between bearings we have the rules:— $L=\sqrt[3]{(d\times 16)^2}$, or $L=(d\times 16)^{\frac{2}{3}}$

$$A=\sqrt[2]{L^3}\div 16, \text{ or } d=L^{\frac{3}{2}}\div 16.$$

In which d=diameter of shaft in inches, L=length between bearings in feet." It may be here remarkedthat a little allowance should always be made for looms on account of the intermittent or reactionary nature of the work.

Unwin, in his "Elements of Machine Design," says that "ordinary mill shafting for textile manufactures" is calculated on a basis which gives the diameter "1·34 times that which would be necessary if they were no bending when as usual it is of wrought-iron," and he gives the following equation:

$$D = 1·34\ B\ \sqrt[3]{\frac{H.P.}{N}} \qquad = 4·414\ \sqrt[3]{\frac{H.P.}{N}}$$

$$\frac{H.P.}{N} = 0·01163\ d^3$$

From this formula he has computed a table, giving the value of $\frac{H.P.}{N}$ for the most ordinary sizes of shaft, from which the following are extracts:—

Diam. of shaft.		$\frac{H.P.}{N}$
2 inches	...	0·0930
3 ,,	..	0·3139
4 ,,	..	0·7442
5 ,,	..	1·4536, and so on.

In using the table he "multiplies the tabular numbers in the column $\frac{H.P.}{N}$ by the number N of revolutions per minute, the result is the horses power the shaft will transmit.

Having these rules for finding the capabilities of shafts

or gearing for transmitting power, it now remains to find what is the power required to be transmitted.

What is termed a unit of work, is one pound avoirdupois raised vertically one foot; then if U denotes the unit of work in raising W lbs. h feet, $\therefore$ $U = W h$.

Thus the rule to find the units of work in raising a given weight a given height is:

Multiply the height in feet by the weight in pounds (or *vice versa*), the product will be the units of work done.

Example.—Find the units of work in raising 5 cwt. 20 feet high. $\therefore$ U = 560 × 20 = 11,200 units of work.

It is important to observe in the application of the above formula to practical cases that the height (h) is the vertical distance through which the centre of gravity of the body whose weight (W) is raised, consequently the work done in raising a body up an inclined plane or any curved surface is equal to the work done in raising the body vertically through the height of the inclined plane.

What is termed a *horse power* is 33,000 units of work done in one minute. Then the following is the formula, H = horse power; U = units of work done; T = time. Therefore $33{,}000 = \frac{U}{60. T.}$

The moving power which is applied to any machine moving uniformly, is employed in overcoming the resistance of friction, and useful work done at the working points of the machine. Hence the aggregate number of units of useful work yielded by any machine at its working points is less than the number received by the machine directly from the moving power by the number of units expended upon the resistance of friction (when the machine moves uniformly). Then the following general rule will find the work done by any machine.

Find the distance through which the power (P) applied to the machine has travelled in one minute, and call this distance (a).

Find the distance through which the weight (W)

producing useful work has travelled in one minute, and call this distance (b).

Then $a\ P - b\ W =$ power expended upon friction in one minute, and $a\ P =$ work applied per minute, and $b\ W$ useful work done per minute.

It will be obvious from this that too close attention cannot be paid to the working parts of the loom so as to reduce the friction to a minimum, and so balance the working parts of the loom as to utilize to the utmost the power applied. By doing this not only will the power be economised but the reactionary nature of the movements of some of the working parts will be modified, and thus not only conduce to the general good working of the loom, but reduce in a considerable degree the wear and tear, and so effect an economy in that direction which is not even secondary to the economy of power.

In dealing with the details of the loom it may be that I have overlooked some minor points. My object has been to deal broadly with the subject, believing that the best and only satisfactory course is to deal with the general principles, and only such details as are necessary to make them intelligible, instead of dealing with a number of petty details which may be applicable in one case and inapplicable in another.

I may venture to quote the words of M. Bautain (Vice-General and Professor at the Sorbonne), who says, "If in the teaching of the natural sciences the professor limits himself to practical experiences, to describe facts and phenomena, he will, no doubt, be able to amuse and interest his listeners, youth particularly, but then he is only a painter, an experimenter, or an empiric. His is natural philosophy in sport, and his lectures are a kind of recreative sitting. To be really a professor he must teach, and he can only teach through ideas; that is, by explaining the laws that rule facts, and in connecting

them as much as possible with the whole of the admirable system of creation. He must lead his disciples to the heights that command facts; down in the depths from whence spring phenomena; and there will only be science in his teaching if he limit it to some heads of doctrines, the connection of which constitutes precisely the science of which he is the master. He will then be able to follow them in their consequences, and to confirm their theory by applications to mechanical and industrial arts, or to any other use to which they may be applied by man."

DESIGNING.

What is generally understood as designing for textile fabrics consists of the arrangement and combination of threads so as to form a pattern on the fabric, whether this fabric be of a plain texture, and the pattern produced by combination of colours, or otherwise. It is not in the mere mechanical act of placing these threads together, but in the arrangement of them so as to produce patterns, whether it be by forming figures with the threads themselves, or in making patterns with threads of various colours, that the skill of the artisan is called forth, and the necessity for technical training made apparent. Any one may be taught to perform the mechanical operation of weaving in a short time, but it is only by careful training and constant attention that the art of weaving can be thoroughly acquired. The arrangement of patterns for weaving is generally performed by one man for a large manufactory, and is dignified by the title of designing, whether or not the class of goods manufactured require any of the skill of the designer, or whether there is anything in the nature of the pattern which can give it any claim to the dignity of a design.

Designing is a part of manufacturing which seems to be generally misunderstood. Given some knowledge of the principles of art and the theory of colour, the one thing necessary to study is the principle of the construction of cloth.

The principle of the construction of cloth may be based upon three distinct classes, viz., plain cloth, figuring, and gauze or cross weaving. (In these three classes lace and knitted cloths are not included). In taking these three principles as the foundation of all weaving, I am

quite aware that I am departing from what has been laid down by previous writers, but I will endeavour to justify this departure. Murphy, in his treatise on the "Art of Weaving," lays down six principles, viz., "plain textures, twilling, double cloth, spotting, flushing, and crossed warps or gauze." A recent American writer lays down only four principles, viz., "plain cloth, twilling, spotting, and plain figured double cloth." It will be noticed that this writer ignores entirely the gauze, which is certainly an important branch of textile manufacture, and the construction of gauze cloth is founded on a principle quite separate and distinct from all others.

One of the difficulties of the student in the art of weaving has been the want of classification and

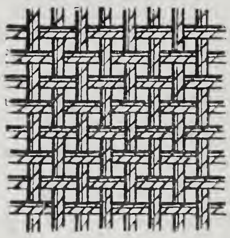


Fig. 39.

arrangement of the principles of construction of cloth, and a consequent want of knowledge and system in the combinations to produce the different patterns and effects desired. The student of music had his notes reduced to a system; the art student had his leading forms and his system of colour,—in these three a similar system is involved; the musician has his primary and secondary notes; the artist his primary forms with combined secondaries, and his primary and secondary colours, out of which all others are manufactured. In like manner the weaver may have his primary cloths, out of which he may form secondaries, and from them a multiplicity of combinations and effects.

Having laid down the three principles, plain, figured, and gauze, I will endeavour by going through them *seriatim* to show that they underlie and are the foundation of every description of cloth.

Plain cloth is formed by the warp and weft threads crossing each other at right angles, and passing under and over each other alternately, thus presenting on the surface something like the appearance shown at Fig. 39, and if taken in section it presents the appearance shown at Fig. 40. This is undoubtedly the very first principle in the

Fig. 40.

construction of cloth, and was probably practised by the ancients for ages before any attempt was made at ornamentation by forming patterns with the threads. Although this is the plainest and simplest make of cloth, it does not necessarily follow that the cloth must be absolutely plain if made on this principle, but it may be infinitely varied by combinations of colours and materials, and some of the most beautiful effects produced in the simplest manner. Plain cloth is for the strength and quantity of material that may be put in it the firmest and strongest of all makes.

Figured cloth covers a very wide range, although the principle is quite as simple in itself as plain. Fig. 41 is

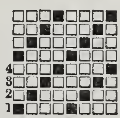


Fig. 41.

a very simple form of figured cloth. If a section be taken at the first pick of the pattern, which is represented by the first horizontal line, numbered 1, it will present the

appearance shown at Fig. 42. If a section be taken at the second pick, shown by number 2, it will present the same appearance, but the weft not passing under the same end as the previous pick, and so on throughout the pattern. It will thus be observed that the pattern is formed by

Fig. 42.

warp and weft threads each passing over and under such a number of threads at a time as is necessary to form the pattern. The number of threads over or under which the warp and weft pass need not be of a limited or a regular character, it may be one or any number. Although this is undoubtedly a figure, it is commonly known as a twill pattern, which is nothing more or less than a figure of a regular description.

It now devolves upon me to prove that every make of cloth which is not a plain cloth, which of course

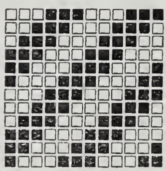


Fig. 43.

admits of no variation in its construction, or a gauze cloth, which is constructed upon a totally different principle, must be either a figured cloth or a combination of two or more of the three principles. This I will endeavour to do in as clear a manner as possible.

In Fig. 42 it has been shown that the figure or pattern is formed by the warp and weft threads passing over and under one or more threads at a time, consequently in every pattern where this occurs the same principle is involved. We will take the case of a regular twill, as is shown at Fig. 43.

On examination it will be found that the warp and weft threads each pass alternately over and under three threads; but by the arrangement of the pattern they do not pass over and under the same three threads every time, but move one thread to the right at every pick, thus forming a regular and continuous twill, but this twill is nothing more or less than a regular and continuous figure. We will take the case of another twill, Fig. 44. This twill is also regular

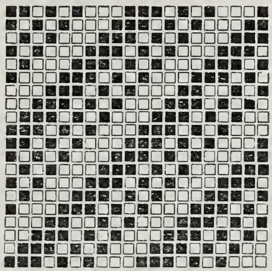


Fig. 44.

and continuous, but on examination it will be found that alongside the twill there are four ends that are working plain, that is, the warp and weft threads pass under and over each other alternately; consequently this twill is a combination of the figure and plain principle. Another illustration, Fig. 45, will demonstrate this even more fully. In this pattern will be found the continuous twill, a decided figure running alongside it, two ends plain running up the twill and three ends plain running alongside the figure, yet only two distinct principles are found to be contained in it. And no matter how extensive or how elaborate a twill—or, as large patterns of this description are called, diagonals or diagonal twills—may be, only the two principles of plain cloth and figuring are involved, the name of twill or diagonal only signifying that the pattern runs in a regular and particular direction.

Spotting is of two kinds; either the spot is formed

by raising the warp or weft, which forms the ground of the cloth, or both, or the spot is formed by a separate colour of warp or weft, or both, which is thrown in for this

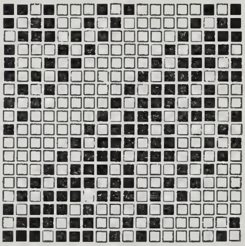


Fig. 45.

purpose ; but whichever of the two methods is employed the spot must be formed upon the principle shown at Fig. 45, and the ground may be either plain or figured as the case may be, but as in the case of Fig. 45 only the two principles are involved. This will be fully demonstrated in another chapter.

Double cloth may be divided into three kinds. First, double-faced cloth, both faces being formed by warp, all the weft being thrown in the centre between them. In this case the two faces may be of different colours by having the warps different. Fig. 46 shows a section of this kind of cloth, the small dots representing one colour of warp, the large dots another colour, and the waved line the weft—which may be of an indifferent colour—passing between them. It may appear from the section that the weft would appear on both sides of the cloth, and so it would if the cloth were of a thin and meagre description, but if the warp threads are very fine and close

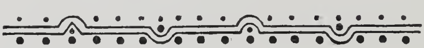


Fig. 46.

together the weft may be entirely hid, because it only passes to the surface of the cloth over one thread, and

the threads on each side would close over and cover it. Second, double-faced cloths, both faces being formed by the weft, the warp being in the centre. A section of this is shown at Fig. 47. In this case as in the previous one

Fig. 47.

the two faces may be of different colours by using two kinds of weft as indicated in the figure, one for the top side of the cloth and the other for the under side, the warp being of an indifferent colour, the cloth being constructed on the same principle as the previous one, only the weft taking the place of the warp on the surface, and the warp passing to the middle. Third the two cloths may be separate and apart from each other. A section is shown at Fig. 48 of a double plain cloth. In this it will be

Fig. 48.

observed that the two cloths are quite apart from each other, and the question will naturally occur to the student, that if a double cloth be made in this manner the two cloths will separate, but to obviate this a very simple precaution is taken. In the process of weaving a thread of one cloth is taken into the other at regular intervals, to bind them together, care being taken to do it in such a manner that it shall not be visible or cause any unsightliness on the face of the cloth. With this I shall have to deal more fully in a future chapter.

Upon this principle of making double cloths there is unlimited scope for making patterns. The two cloths being apart from each other, may be totally different in colour and pattern, or patterns may be formed by having

the cloths of different colours, and bringing one cloth through the other so as to form a figure on the face of it.

In the case of double cloths no new principle is involved; it is again a figured effect, a plain cloth, or a combination of the two. In the case of the double warp face the effect is produced by the two warps working on the figuring principle, more or less according to the pattern. In the case of the double weft face the effect is produced by the two wefts working on the figuring principle, and in the case of the two separate cloths it is two plain cloths, or two figured cloths, produced by keeping each separate weft to its own warp, no matter whether the two cloths remain separate, on whether one cloth is made to form a figure on the other.

Pile or plush weaving is of two kinds, loop pile and cut pile. The way in which this is produced is by having, in addition to the usual warp and weft threads, a third thread which is introduced as warp, and woven into the ground, and formed into loops on the surface of the cloth, by being woven over wires of a length equal to the breadth of the cloth. In the case of a loop pile the wires are simply drawn out, but in the case of a cut pile the wires are cut out by passing a sharp knife along a groove in their upper surface, or by having a sharp knife affixed to the end of the wire, which cuts its way as the wires are drawn out. Fig. 49 shows a section of the wire used for making the loop; the groove on

Fig. 49.

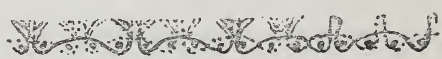


Fig. 50.

the upper surface guides the knife, which is fixed in what is known as a trevet, and drawn sharply along it to cut the pile.

Fig. 50 is a section showing the structure of a plain or

what is known as Utrecht velvet, one portion of it being left uncut for the purpose of showing the loop.

Another method of making a cut pile is by making it with the weft. In this method the ground of the cloth is woven plain or twilled and the weft which is to form the plush is allowed to pass over the face of the cloth a sufficient distance to form the length of plush required. A sharp knife is then taken, having, in front of and fixed on it by means of a groove, a guide, the size of the guide being regulated by the length of the plush. The point of the guide is inserted under the loose weft on the surface of the cloth, and pressed forward, and as it slopes up it raises the weft up to the edge of the knife, which severs it. Fig. 51

Fig. 51.

shows the section of this kind of plush before being cut, though the length of pile is much less than usual, and Fig. 52 shows the cutting knife, *a* being the guide.

Fig. 52.

If the reader has followed carefully the foregoing he will have observed that the ground cloth is perfectly plain in both the warp pile and the weft pile cloth, and that the pile or plush is worked on the figuring principle. And to whatever extent it may be carried, whether the plush be bound down by a single end, or, as often happens, the plush is woven into the ground cloth for a considerable distance, sometimes for the purpose of producing patterns and sometimes for the purpose of more securely binding the plush into the cloth, yet the same principle remains, viz., a combination of plain and figure.

Numberless combinations of these two fundamental principles may be affected, but I have selected the principal and most characteristic ones for the purpose of illustrating

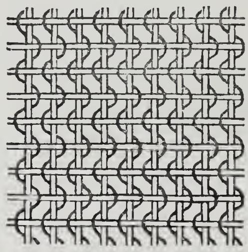


Fig. 53.

the theory I have laid down. It now remains for me to show the nature of the third of these fundamental principles, and the combinations that may be effected with one or both of the other two.

The essential feature of gauze weaving is, that the warp ends and the weft do not necessarily cross each other at right angles, but in plain gauze, for instance, between every pick of weft the warp threads are made to cross each other, or, as it were, to twist half round each other, so that the weft threads are held separate, as shown at Fig. 53 and the section Fig. 54, and a light transparent texture

Fig. 54.

is produced. In fancy gauzes the threads are crossed so as to make a pattern. The means of producing this effect will be fully described in a future chapter, the object at present being to show the nature of the fabric and the principle of construction. By combining this kind of weaving with one or both of those previously described some beautiful effects are produced. These combinations may be in such an immense variety of forms that it

would be impossible to go through them in detail within the limits of this work, indeed much of it must be left to the taste and ingenuity of the designer. I shall content myself by giving in the chapter devoted to the practical consideration of this branch of the subject the details of a few leading effects which form the basis of gauze cloths.

COMBINATIONS AND ARRANGEMENT OF DESIGNS.

Having in the last chapter indicated the principle upon which cloths are constructed, we will now proceed to deal with the practical part of the question, and examine in detail the various combinations spoken of and the simplest and easiest methods of arriving at them, and by going carefully step by step through the various stages endeavour to place the subject before the reader in such a manner as to make it perfectly intelligible.

In designing for textile fabrics, as in designing for anything else, the first thing requisite is some system of arranging upon paper the pattern which is intended to be woven upon the fabric. This is done by having paper ruled in small squares as shown at Figs. 43 to 45. The first thing which it is necessary to impress upon the student with reference to this paper is, that the spaces between the lines are intended to represent the warp and weft, and not the lines themselves, the vertical spaces representing the warp and the horizontal spaces the weft, the pattern being arranged by filling up the desired spaces.

In the texture of plain cloth, as shown in the previous chapter, the threads cross each other over and under

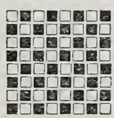


Fig. 55.

alternately. This is shown upon the design paper at Fig. 55; the squares which are filled in black showing the weft

thread passing over, and in the squares left open passing under the warp thread. That being the case, every alternate thread of warp or weft works exactly alike, that is, passes under and over the same threads, consequently two ends and two picks represent the whole pattern as in Fig. 56. It would seem at first sight that plain cloth cannot be ornamented except by an arrangement of coloured threads. Strictly speaking this is so, but plain working may be made the basis of a system of figuring exceedingly simple in itself but very effective in certain classes of goods. If we take the example shown at Fig 57 we have a plain cloth, but so arranged that two warp

Fig. 56.

Fig. 57.

Fig. 58.

threads work together as one throughout the piece, which will give the piece a corded appearance, the cords running lengthwise with the piece. These cords will be made more distinct as the weft is made to preponderate over the warp. Again, in Fig. 58 we have a similar arrangement, but in this case the warp threads work separately as a plain cloth and the weft goes in two picks as one; this would produce a cord running across the piece, or in the direction of the weft. In like manner, in Figs. 59 and 60 we have a warp and a weft cord formed by

Fig. 59.

Fig. 60.

three warp or three weft threads working together. Again, we may have cords of varying sizes, large and small alternately, as shown in Fig. 61, where the cords consist

of one and three ends respectively; or we may combine the two cords and produce a decided figure as shown in

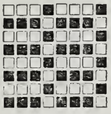


Fig. 61.

Fig. 62.

Figs. 62 and 63. In combining two workings of this kind some care and skill is requisite in joining them so as to prevent an imperfection at the junction, and it will be well to call attention to it now, so that the same

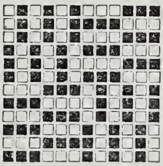


Fig. 63.

principle may be observed in future combinations. If we turn, for example, to Fig. 62, it will be seen that at the junction of the two cords the weft or warp passes under or over three threads. In some goods this might produce a little unsightliness, trivial as it may appear, but it can easily be obviated by so arranging the pattern that the first and last end or pick of each pattern becomes as

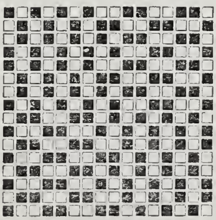


Fig. 64.

much a portion of the pattern to which it is joined as of the pattern to which it actually belongs. This may be illustrated by Fig. 64, which is the same arrangement on a larger scale, and in which the ends and picks which

form the junction of the pattern—the eighth and ninth, for instance—each form part of both patterns. In this manner, and with the exercise of care and ingenuity, a great diversity of patterns may be produced upon the basis of plain cloth.

Next to plain cloth in its simplicity and extent of application comes twilling, which may be considered the first step in figuring. In twilling two objects are aimed at, viz., to give strength and weight to the cloth, and to ornament the surface in a pleasing manner. It must not be understood by giving strength to the cloth, that with a given number of threads of given strength per inch twilling would produce a cloth as strong as a plain cloth, because from the very nature of a plain cloth, the threads crossing each other alternately, nothing could possibly be stronger; but by twilling a greater number of threads per inch, both in the warp and weft, can be put in than can possibly be put in plain cloth, the character of the working allowing the threads to lie closer together, and consequently produce a stouter fabric.

The number of twills which may be woven is very extensive, but they may be conveniently divided into three kinds, and treated under the following heads: regular twills, broken or satin twills, and fancy twills. The first to claim our attention, as being the first removed

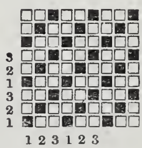


Fig. 65.

from plain cloth, are the regular twills. In this kind of twill the small stripes formed by the intervals at which the warp and weft threads cross each other run obliquely across the cloth, which is produced by the warp threads

being raised in consecutive order, commencing at one side and following the direction the twill is intended to take. We will commence with the first variation or change from plain cloth, viz., the three end twill shown on Fig. 65, in which every third end is raised or depressed in succession, the weft passing over or under the other two. This is done by having three healds, the warp being drawn through them, and the healds raised to allow the weft to pass through in regular succession from front to back. A simple method employed for indicating the draught or order in which the ends are drawn through the healds, is shown at Fig. 66, the horizontal lines representing the healds and the numbers the warp threads; the position of the numbers on the horizontal lines showing the healds through which the thread is drawn; or vertical lines may be substituted

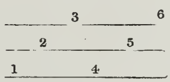


Fig. 66.

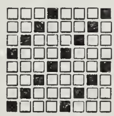


Fig. 67.

for the figures, and will be found to work even better in practice than the use of numbers. The four-end twill, Fig. 67, is similar to the three-end twill; in this case the weft passing over or under three threads and interwoven at the fourth. For this four healds are required, the warp threads being drawn through, and the healds raised in

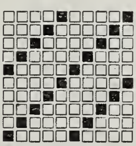


Fig. 68.

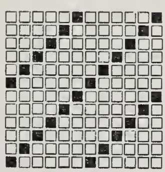


Fig. 69.

regular succession as before. Twills of five, six, or any number of ends may be worked in a similar manner, the

number of threads in the twill being drawn on a corresponding number of healds, and raised in consecutive order as shown, Figs. 68 and 69.

It is not necessary that regular twills should be confined to one thread rising or sinking at once, but any number into which the pattern may be divided may be raised or depressed together. Take the case of a cashmere twill, Fig. 70. In this there are four ends, the weft passing over and under two. The draught of this is the same as Fig. 67, but instead of one heald being raised at a time

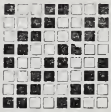


Fig. 70.

two are raised, each heald remaining up for two picks, but so arranged in their order of succession that one is depressed and another raised to take its place at every pick. Fig. 71 is a five-end twill with the weft passing over two warp

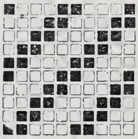


Fig. 71.

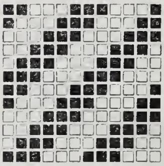


Fig. 72.

threads and under three, the order of working being precisely the same as in Fig. 70. Fig. 72 is another of the same description, the weft passing over three and under three warp threads, and so on *ad infinitum.*

Before proceeding further with twills, it will be advisable to examine the reason why a twill should be made to run in a particular direction. In nearly all twills one great object aimed at is clearness or closeness of the twill, so that the cloth may look as fine and compact in its structure as possible. To attain this result the direction of the

twill must be determined by the twist of the weft and warp, and should run in a direction contrary to both, and to do that the warp and weft should be contrary to each other in twist before being put together. This may be illustrated by Figs. 73 and 74. In Fig. 73 the warp and weft are placed at right angles to each other as they

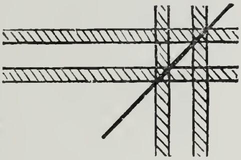


Fig. 73.

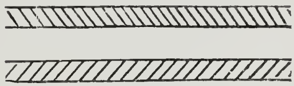


Fig. 74.

would be in the cloth, and it will be observed that in this position the twist of both runs in the same direction, but in Fig. 74, where they are laid parallel, the twists run in opposite directions; then the twill, which is represented by the dark line in Fig. 73, runs in a direction contrary to both. The result of this arrangement is that each thread of warp or weft in forming the twill becomes partly embedded over or under its immediate neighbour, and so produces a closeness and fineness which could not be obtained by any other means. If a twill cloth be examined it will be found that on one side, which corresponds with this arrangement, the appearance is all that could be desired, but on the other side of the cloth, where the reverse is the case, every thread stands out separate and distinct, and gives the cloth a very unpleasant appearance.

In some cases, where the warp or the weft predominates very largely, it may not be of much importance what is the twist of the other, because being so much hid it could not have a very material effect on the appearance, but except in such cases this rule should be very carefully observed.

We may now begin to combine plain with twill, and produce a pattern which will give a firmer texture to the cloth, having somewhat of the character of the plain cloth with a twill pattern upon it. Fig. 75 is a twill of this description, and in point of texture is nearest to a plain

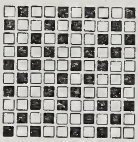


Fig. 75.

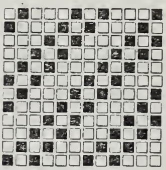


Fig. 76.

cloth, three of the five threads working plain, the weft passing over or under the other two to form the twill. Fig. 76 is another; this pattern is composed of six threads, three plain and three forming a twill. Fig. 77 is a still

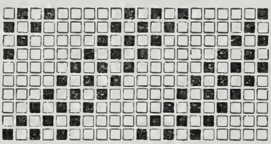


Fig. 77.

more extensive one, five threads working plain and five forming the twill.

In the three patterns, Figs. 70, 71, and 72, the twill is formed by the weft passing under and over a regular number of threads in regular succession; in the patterns Nos. 75, 76, and 77, the twill is formed by a number of plain ends and intervals of warp, over or under which the weft passes. We may now combine the two, and by this means produce beautiful and elaborate patterns, to the extent and variety of which there is scarcely any limit. Begin with Fig. 78, which is a cashmere twill with two ends plain

run along it, so making it into a six end twill; Fig. 79, which is three weft and three warp twill, with two ends plain;

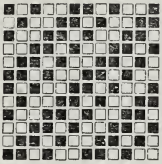


Fig. 78.

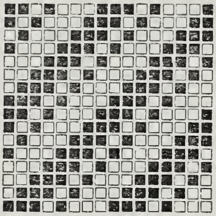


Fig. 79.

Fig. 80, with two ends plain running up between each weft and warp twill; and Fig. 81, with four ends plain running up one side of the weft twill.

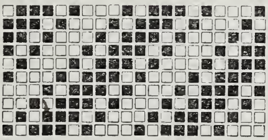


Fig. 80.

Before entering upon fancy twills it will be necessary to point out an important feature in the arrangement of the design, which is not only applicable to twills, but to every design for textile fabrics of every description. The design must be so arranged that the pattern will be continuous and unbroken all over the surface of the fabric. To do this, care must be taken that at each repetition of the pattern the joining must be complete and perfect. Take the case of the pattern Fig. 65. The complete

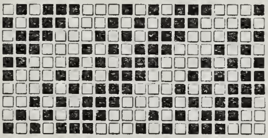


Fig. 81.

pattern is produced upon three warp threads and three weft threads, No. 1 being a repetition of No. 1, No. 2 of

No. 2, and No. 3 of No. 3, both in warp and weft; thus three threads constitute what is termed the round of the pattern, and however often repeated no break will occur in it. On examination this will be found to be the case with all the patterns, the point at which the pattern begins to repeat determining the number of healds that will be required to weave it. Each of the patterns given here as illustrations will be found to be repeated for the purpose of showing this clearly.

As I explained in the previous chapter, all twills are figures of a regular kind, that regularity being determined by the twill or figure running in a particular direction; the few examples just given will have served to some extent to illustrate it, but fancy twills, or, as they are more frequently termed, fancy diagonals, will more fully prove this. Fig. 82 is a pattern which is composed of plain, regular twill, and figure, the result being a decidedly fancy pattern. Fig. 83 is another of similar combinations. But the figuring of fancy diagonals need not be confined to this character of figure. Fig. 84 is an example of an altogether different type. Others of a more extensive and varied character may very easily be produced.

One important rule must be borne in mind in the arrangement of patterns of this description, viz., that the

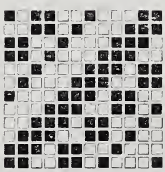


Fig. 82.

number of ends occupied by the figure must be such a number as will divide in the number occupied by the diagonal, without leaving any remainder, or the pattern must be repeated over and over again, until a number of ends or picks is reached in which each will divide without

leaving any remainder, or in other words, a number of which each is a measure. In determining this the figure must be counted in a diagonal direction, because as it runs continuously in a diagonal direction, the number of ends or

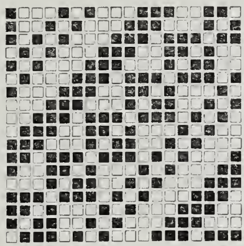


Fig. 83.

Fig. 84.

picks which it occupies could not be determined in a horizontal or vertical direction, and even if the ends and picks could be determined in the horizontal and vertical directions it would be of no avail, because it is only in the diagonal direction that it bears any relation to the other portions of the pattern.

If we examine Figs. 82 and 83, we shall see that the figure occupies a number, counted diagonally, which divides in the number occupied by the twill; consequently they are perfect at one repetition. Supposing in Fig. 83 the number

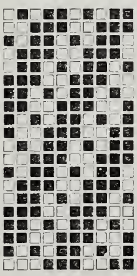


Fig. 85.

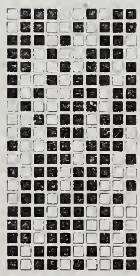


Fig. 86.

of ends occupied by the figure counted four diagonally, the twill portion occupies eighteen ends and eighteen picks; then to make the pattern complete, four not being a

measure of eighteen, the pattern would have to be repeated to thirty-six ends or picks, because eighteen is a measure of thirty-six, and so is four. By adopting this method of calculating, the number of ends and picks which will be required to complete any pattern which is a combination may be determined at once.

In all the examples given here the twill moves only one thread at a time, that is, on each successive pick the pattern moves one thread to the right, so that supposing there are the same number of threads per inch in the weft as there are in the warp, the twill will run at an angle of forty-five degrees across the piece; but very excellent effects are often produced by making the twill to run at an angle of more, or less, than forty-five degrees. Fig. 85 is an example of a twill in which the pattern, instead of

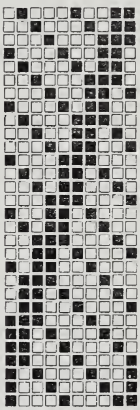


Fig. 87.

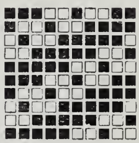


Fig. 88.

moving one thread every pick, only moves one thread every two picks, consequently the twills run across the piece at a very much higher angle. Fig. 86 is another example of twill of a similar arrangement, Fig. 85 being a single twill and Fig. 86 a double twill. To obtain variety of pattern the twills may be placed further apart, and twilling running in the opposite direction, as Fig. 87,

or figures of various kinds introduced between them. The angles of the twill may easily be altered by moving more or less frequently. Fig. 87, for instance, only moves one thread every three picks, while Figs. 88 and 89 move two threads at each pick. A comparison of the designs will show how easily an immense variety of patterns may be produced.

Similar effects may be produced, as will be shown by combination of two twills, or by elongation.

The class of twills which next claim our attention are totally different from those with which we have just been dealing, and are known in the trade as broken or satin twills. In the twills we have just had under consideration the pattern follows in regular order, but in satin twills this is not the case; instead of the threads being interwoven

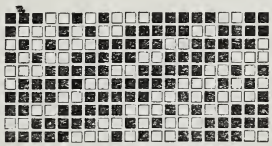


Fig. 89.

in regular succession, they are interwoven at intervals of one, two, or more.

It may be observed of satin twills that some are perfect in respect to the intervals at which the threads are interwoven, and some are imperfect. The lowest satin twill that can be produced is the four-thread satin, which is

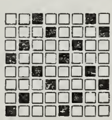


Fig. 90.

Fig. 91.

sometimes called the satinet twill. This is shown at Fig. 90, and is one of the imperfect ones, inasmuch as on two successive picks the interwoven threads are next to each other. The five-end satin, Fig. 91, is a perfect one; it

will be found that every thread is interwoven at regular intervals. Before proceeding further it will perhaps be advisable to explain the system upon which satin twills are arranged. Take Fig. 91 as an example; the pattern is twice repeated, so as to show more clearly how it runs; on the first pick the first thread is taken, on the second pick the third thread, on the third pick the fifth thread, on the fourth pick the second thread, and on the fifth pick the fourth thread, so that all through the pattern there is always one thread passed over between those that are interwoven. Perhaps the following method will simplify the arrangement somewhat. Make five dots to represent the number of threads, Fig. 92; under the first dot place number one, then pass one and place number two, pass one again and place number three, pass one again (this

. . . . .
1 4 2 5 3

Fig. 92.

time it will be the first end you pass) and place number four, pass one again and place number five; passing one again brings you back to number one, thus proving that the satin is perfect, the intervals being regular throughout, or in other words, the five dots are treated as if they were a continuous series, and are passed over repeatedly until every end has a number placed under it. The dots are then treated as representing the warp threads, and the numbers as representing the weft threads which pass over them, thus on comparing Figs. 91 and 92, it will be seen that they exactly correspond.

A six-thread satin is an imperfect one, and may be arranged in two ways; in one case two threads come

. . . . . .
1 4 2 5 3 6

Fig. 93.

. . . . . .
1 4 2 6 3 5

Fig. 94.

together, in the other case they do not. The two arrange-

ments are annexed, Figs. 93 and 94, and Figs. 95 and 96 being the corresponding designs.

A seven-thread satin, Fig. 97, is a perfect satin, passing one thread at a time, or having what is termed a basis of two, as is also an eight-thread satin, Fig. 98, passing two at a time, having a basis of three.

From the foregoing it will be seen to be an easy matter to arrange a satin upon any given number of ends, but in some cases care must be taken as to the direction of the twill to suit the twist of the material used or the character of effect intended to be produced on the surface of the fabric. It has been pointed out in page 175 that to produce certain effects on twills the direction of the

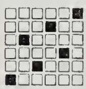


Fig. 95.

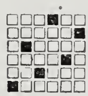


Fig. 96.

twill will be governed by the twist of the warp, or weft, or both; the same thing holds good of satins. If we take for example the five-end satin, Fig. 91, it will be seen on careful examination that a decided twill runs across the piece in the direction of the weft from left to right, or in the direction of the warp from right to left. This twill will be more decided in one direction or the other as the weft or warp predominates. In all satin cloths

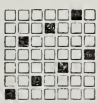


Fig. 97.

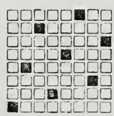


Fig. 98.

one material or the other is made to predominate very largely; then if in this case the weft has that predominance, the twill will run from left to right in a nearly horizontal line, the warp being quite invisible, or, if the warp predominates, the twill will run from right to left in a nearly vertical

line, and the weft will be invisible. In the first case the twill may be made more distinct by running it to suit the weft, or less distinct by running against it; in the latter case it will be more distinct by running to suit the warp, or less by running against it. In all cases the first consideration should be, whether it is to be warp or weft face; secondly, whether the twill is to be visible or not, and then adapt the twill to the twist of the material.

It must not be supposed from the foregoing that upon any number of ends there can be but one satin arrangement, for any number which is not a measure of the total number of ends employed may be used as a basis of satin arrangement, and in many cases will produce very different effects For example, upon seven threads there are two arrangements possible, viz., one having a base of two, and one having a base of three. The first is shown at Fig. 97, the second at Fig. 99. In one sense they are of course similar, that is, the character of the twill is similar in both cases, but one (Fig. 97) shows a somewhat decided twill running horizontally from left to right, and the other a similar twill running vertically from right to left.

From what has been suggested, that a satin may be arranged upon any base which is not a measure of the total number employed, it would seem that upon seven threads

Fig. 99.

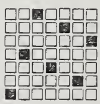


Fig. 100.

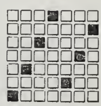


Fig. 101.

there are seven possible satin arrangements; that is, there are four numbers which could be taken as basis, viz., two, three, four and five. Of course one could never be taken as a base, because the points of intersection would follow consecutively, and would therefore form a regular twill. That being so, six being one less than seven, a regular twill

would be formed in the opposite direction. Again, five being two less than seven, an arrangement exactly similar to that having a basis of two would be produced, thus, Fig. 100 is exactly the reverse in effect to that shown at Fig. 97, and four being three less than seven, the same effect would be produced as if a basis of three were employed, so that Fig. 101, with a basis of four, is exactly the reverse of Fig. 99.

It must not be supposed from this that upon all numbers of ends there can be only two arrangements possible, and that those would virtually produce the same pattern, but running vertically and horizontally respectively. Upon some numbers, such as eight and twelve for example, there is but one possible, viz., a basis of three, for although five appears to be available, it is simply three less than eight, and consequently must produce the same result. In

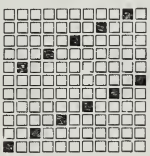


Fig. 102.

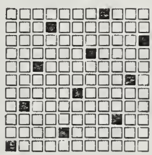


Fig. 103.

the same way with twelve, only a basis of five is available. Again, nine threads correspond with the conditions which govern seven, and ten with those which govern eight, but upon some other numbers, such as eleven and thirteen, there is more scope, and the result of this difference may be to produce what might be called a decided twill, with one base, and very even distribution with another. Take for example the two patterns, Figs. 102 and 103, the first of which shows a decided twill, and the second a tolerably even distribution. The effect upon the cloth would be that one would show a much more decided pattern than the other.

Upon other numbers of threads similar results may be obtained, the one thing to bear in mind being that whenever the number upon which the satin is based is more than half

the total number of threads employed, the result will be the same as another which has less than half the total number for its base.

Before we proceed further with the production of new patterns or new combinations, we may venture to return to those we have already gone over, and examine what extent and variety of patterns may be produced upon a given number of ends, and what variety of combinations may be produced with a given pattern as the basis. In the plain cloth it has already been shown that, strictly speaking, there can only be one working for plain, but that a variety of patterns may be produced with plain as the basis. The same may be said of a three-end twill, which is the first removed from plain cloth. Confining ourselves to three ends, nothing but twill could be produced, but, based upon this twill, different patterns

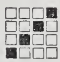
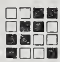





Fig. 104. *Fig.* 105. *Fig.* 106. *Fig.* 107.

may be produced. This will be dealt with later, for the present confining ourselves to what can be done upon a given number of ends. Confining ourselves then to three, little more than the twill given at Fig. 65, page 172, can be formed, but one or two effects might be produced, such as Fig. 104, which is nothing more or less than alternate picks of the same twill, the one with weft and the other with warp preponderating. Then taking four ends, we find that we have considerably more scope. Three patterns have already been given, Figs. 67, 70, and 90, which are worked upon four ends, Figs. 67 and 70 being regular twills, and 90 a broken twill or satin. Then let us examine the nature of these arrangements and see of what they consist and how they may be varied, and for that purpose we will reproduce them here, Figs. 105, 106, 107. Then assuming

that the black dots represent the weft on the face, and the vacant spaces the warp on the face, each pick in Fig. 105 passes over one warp thread and under three, each succeeding pick moving one thread to the right. This may be varied by running the twill to the left, in that case the figure or pattern moving one thread to


Fig. 108.


Fig. 109.

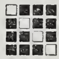


Fig. 110.

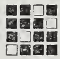


Fig. 111.

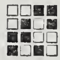


Fig. 112.

the left at each pick, Fig. 108, but in both cases there will be the same preponderance of warp on the face of the cloth. Then Figs. 109 and 110 represent the same twill, but with weft preponderating, so that we have apparently

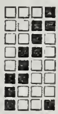


Fig. 113.

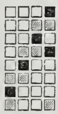


Fig. 114.

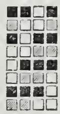


Fig. 115.

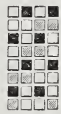


Fig. 116.

four patterns, but really only one. Then if we examine Fig. 107 we shall find it is really the same working as Fig. 105, but the third and fourth ends have exchanged places. In this, as in Fig. 105, we may substitute weft for warp on the face, Fig. 111, the pattern again remaining the same, so that Figs. 107 and 111 are based upon the principle of Fig. 105. And so in like manner with Fig. 106; if we exchange the position of the third and fourth threads, or in fact of any two out of the four, we produce a different pattern, Fig. 112. Then we may go a little further, and combine two of the workings as in Fig. 113, which consists of alternate picks of 105 and 106, the combination being more clearly shown at Fig. 114, where one of the patterns is represented by the solid and the other by the shaded squares. In the same manner we may combine any two, as in Fig. 115, which consists of Figs. 106 and 109. Again,

we may carry the principle further by combining any one of them with another kind of working, as with plain, which is shown in Fig. 116, thus producing a pattern totally different in appearance from any of the others.

If we take five threads and deal with them in the same manner, we may produce considerable diversity of patterns. If we examine Figs. 117 and 118, which are


Fig. 117.


Fig. 118.

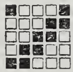


Fig. 119.

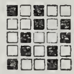


Fig. 120.

the same as Figs. 68 and 91, we shall find the difference to consist solely of a re-arrangement of the position of the threads; or take 119 and 120, the same remark applies, although the appearance of the two twills is

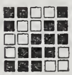


Fig. 121.

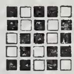


Fig 122.

totally different. Then in Figs. 121 and 122 we have precisely the same arrangement as in Figs. 119 and 120, but with weft substituted for warp on the face, and *vice versa.*

It would be utterly impossible within the scope of this work, to show to what extent this principle of re-arrangement could be carried, and in this treatise it is not necessary. Since the publication of the first two editions of this work I have written two works, viz , "The Album of Textile Designs," and "Design in Textile Fabrics," the latter work published by Messrs. Cassell & Co., Limited, in which the questions of re-arrangement and combinations are fully dealt with.

It may not be amiss however to say a few words here as to the various methods of re-arrangement. Already at page 182 the method of re-arranging patterns in what is called satin order has been pointed out, but there are many other orders besides satin which may well be employed. For

instance, in the latter of the works just mentioned, the arrangement of patterns by transposition of the threads is shown, and in "The Album of Designs" a large number of patterns are given, which are the result of such transposition,

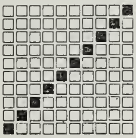


Fig. 123.

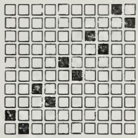


Fig. 124.

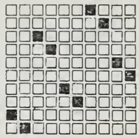


Fig. 125.

but we may not only transpose them in regular order, but we may arrange the transpositions in satin order. Take for example the three patterns, Figs. 123, 124, and 125, the first of the three is a simple straight twill upon ten ends, the second is the same twill with the threads re-arranged in the

2 1 4 3 6 5 8 7 10 9

1 4 2 5 3

Fig 126.

order 2.1.4.3.6.5.8.7.10.9., and the third is the second pattern re-arranged in five-thread satin order. Fig. 126 will show conclusively how this has been obtained.

The dots represent the consecutive order of the original twill, Fig. 123, the numbers above the dots the re-arrangement, by transposing the threads in pairs as shown in

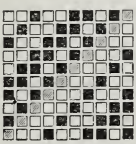


Fig. 127.

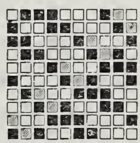


Fig. 128.

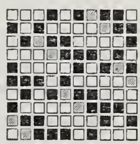


Fig. 129.

Fig. 124, and the numbers below the dots, the re-arrangement of those transposed pairs as shown in Fig. 125.

So far as those three patterns are concerned of course only the principle of the system is shown, because a single line twill of this kind cannot show any decided characteristics,

but when this principle is applied to patterns of a more elaborate character, then the value of it at once becomes apparent. Take for example the patterns shown at Figs. 127, 128, and 129. In each of those patterns the basis of the arrangement is shown by the shaded square. Thus it will be seen that the shaded squares in each of the three patterns correspond with the solid ones in Figs. 123, 124, and 125 respectively.

But we may not only divide a re-arranged or transposed pattern up in the manner shown in Figs. 125 and 129, but in like manner any original pattern may be dealt with thus, Fig. 130 is the same with 123 but re-arranged in five pairs, and Fig. 131 is the same as 127 re-arranged in the same manner, yet the resulting pattern is very different

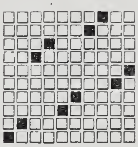


Fig. 130.

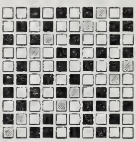


Fig. 131.

in each case, not only from the original, but from those shown at Figs. 125 and 129.

This method of re-arrangement of threads, and of combination of two or more patterns, places in the hands of the designer an immense power for the production of designs.

The combination or re-arrangement of twills, each occupying the same number of threads, will produce new effects, but these are much better, and the effects more varied, when the two patterns combined occupy different numbers of ends. If we were to commence first of all with three-end twill and four-end twill, combined end and end, and in all their varieties, we should obtain a number of different patterns. Again, take four-end twills with five-end twills, and we get another variety, take five-end twill

with six-end twill and we obtain a still greater variety. It would be almost impossible to conceive the number of new patterns which might be produced in this way. In the combination of three and four-end twills we could obtain six patterns as regular twills, and six more by combination of three-end twills with the four-end twills, transposed as in Figs. 107, 111, and 112. In the combination of four and five-end twills we should obtain eighteen regular twills, with the four-end twills transposed and the five-end twills straight forward we should obtain eighteen more, and with the five-end twills transposed and the four-end twills straight forward eighteen more; thus from the combination of four and five-end patterns, no less than fifty-four patterns would result.

In the arrangement of these patterns a similar rule would have to be observed as in the combination of figures and diagonals, of carrying the pattern forward to a number of ends or picks where each will join properly at the same time. Thus, in the combination of three-end and four-end patterns, twelve is the first number of which each is a measure, so that if they are arranged end and end, twenty-four ends would be occupied, and as the picks of each pattern would be concurrent with each other only twelve picks would be required. In the combination of four and five-end patterns, end and end, twenty ends of each and twenty picks would be required to complete the pattern. But although in the latter case forty ends would be required to complete the pattern, the whole could be woven upon nine healds, simply because it consists of two small patterns, each of which can be woven upon four and five healds respectively. More will be said upon this matter when the question of drafting is dealt with.

In the same manner any number of threads may be dealt with, and an immense variety of patterns produced; the greater the number of ends used and the greater the

number of changes which may be effected. I have simply taken here some of the very simplest, for the purpose of showing as plainly as possible the principle. At a later period I shall take some more elaborate combinations. The one thing to which I wish to direct the especial attention of the student is, that every pattern, however intricate and complicated it may appear at first sight, may be reduced by careful analysis to its simplest elements, and then reproduced in an infinite variety of forms; and it is in the ability of the designer to make these combinations suitable to the nature of the fabric upon which he is working, so as to produce the best appearance, that his whole success depends.

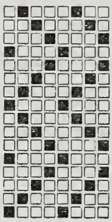


Fig. 132.

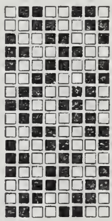


Fig. 133.

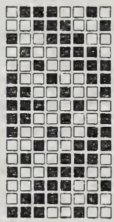


Fig. 134.

We may now proceed to the manufacture of more intricate patterns out of the simple material we have obtained. Instead of twills running regularly across the piece, by simply reversing the twill after weaving a certain distance, so as to run alternately in opposite directions, a pattern of a totally different character is produced. Fig. 132 is an ordinary four-end twill worked in this manner, and forming a zig-zag pattern. Fig. 133 is a cashmere, or two weft and two warp twill altered in the same manner, and Fig. 134 is a larger twill. In each case the twill runs in one direction all across the piece for a certain number of picks, and then reverses.

Before proceeding further in the manufacture of patterns, it will be necessary to point out to the student another

important matter connected with this branch of the subject. All the examples given are woven upon what is termed the straight draught, that is, the warp threads are drawn through the healds in regular order as shown at page 173, but by varying the order of drawing the

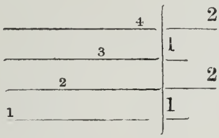


Fig. 135.

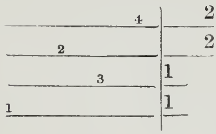


Fig. 136.

threads, an immense variety of patterns may be made upon a very small number of healds. Before entering upon any new patterns which will require a variation in the draught, I must call attention to a rule, the observance of which is absolutely necessary for the guidance of the student, viz.: In arranging the order in which the healds must be raised and depressed, the order in which the warp threads are drawn through the healds must receive the first attention; for instance, in weaving a plain cloth, every alternate end must be raised or depressed, consequently, if they are drawn straight over in regular order as in Fig. 135. every alternate heald must be raised or depressed, as indicated by the numbers. If on the other hand they are drawn on alternate healds, then the first and second would rise together,

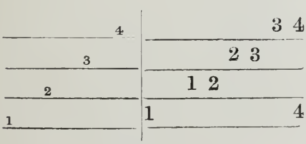


Fig. 137.

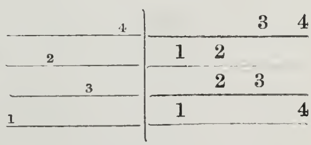


Fig. 138.

and the third and fourth, Fig. 136, the small numbers representing the order in which the ends are drawn through the healds, and the large numbers representing the order in which they are raised. It will be seen that every alternate thread rises together in both cases. Take

again the cashmere twill. Fig. 137 shows the order in which the healds rise when drawn straight over, being precisely the same as shown on the design; then draw it on alternate healds, Fig. 138, and the order in which they require to be raised is shown also.

We will now begin to alter the draught so as to alter the pattern. Fig. 132 is a pattern which would have the

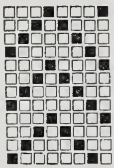


Fig. 139.

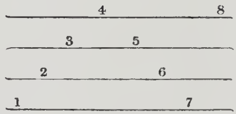


Fig. 140.

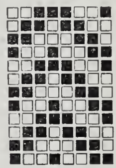


Fig. 141.

appearance of a stripe running across the piece, the pattern being produced by weaving a number of picks with the twill running in one direction, and then a number with the twill running in another direction. Fig. 139 is a zig-zag of the same kind, but instead of the stripes running across, they run lengthwise of the piece. This is done by drawing the required number of warp threads straight forward, from front to back of the healds, and then reversing and drawing from back to front, Fig. 140,

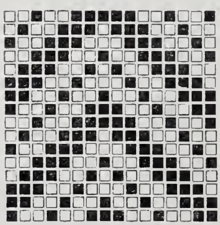


Fig. 142.

and weaving straight forward as if weaving an ordinary twill. Fig. 141 is a cashmere worked in the same manner and Fig. 142 is the same twill as Fig. 134.

In draughting in this manner it is not necessary that the same number of threads should be drawn each way,

but the number may be varied at the discretion of the designer, so as to make large and small stripes, &c.

To produce still greater variety, combine the principle of Fig. 132 with Fig. 139, that is, draw the warp as shown at

Fig. 143.

Fig. 144.

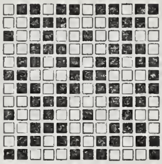


Fig. 145.

Fig. 140, and reverse the weaving to correspond; the result will be to form diamond patterns, as Fig. 143. Gradually extend the patterns, each time introducing a little more detail; for example, Figs. 144 and 145, each of these being

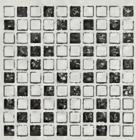


Fig. 146.

woven on the principle of the draught given at Fig. 140. An extension of this system of draughting is given in Figs. 146, 147, and 148. Instead of four healds, six and eight are employed respectively, the order of drawing being precisely

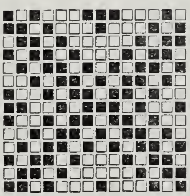


Fig. 147.

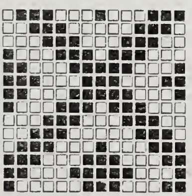


Fig. 148.

the same, viz., from one to eight, and back from eight to one. In these last examples, the first and last healds being the turning points of the draught, it will be noticed that less

threads are drawn upon them than the rest, consequently they would require to be coarser than the rest in sett, that is, would require less heald cords upon them. This may be obviated, and in some instances the patterns considerably improved, by altering the draught so as to commence reversing upon a different heald to the one upon which the last thread is drawn. Fig. 149 is a stripe pattern

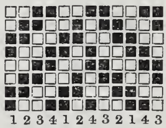


Fig. 149.

drawn upon this system. On examination of the numbers which are placed under the spaces representing the warp threads (these numbers representing the healds upon which the threads are drawn), it will be found that where the twill reverses, the first end, instead of being drawn upon No. 1 heald, as it would be if reversed in the same manner as the previous example, is drawn upon No. 4, the next upon No. 3, and so on. If it is intended to weave a diamond pattern, the same rule must be observed with regard to the picks, see Fig. 150, where the first pick of the reversed portion, instead of being the same as

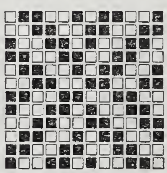


Fig. 150.

No. 1, is like No. 4. By the careful observance of the rule mentioned in pages 194 and 195, the student may now begin to make patterns of a more elaborate kind, by the simple variation of the draughts, and when necessary, reversing the twill in weaving. Fig. 151 is an example of what may

be done in this direction, and by reversing the twill in weaving, a large check effect will be produced. I might give endless examples to illustrate what might be done, but I should only be unnecessarily adding to the size and cost of the work by doing so. I have selected what seems to me the simplest patterns I could possibly find, to convey to the reader as clear and accurate an idea as possible of the principle of weaving.

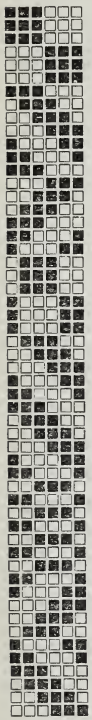


Fig. 151.

Hitherto I have supposed that the draught has been arranged beforehand, and that the patterns have been made to suit the draught. I will now reverse the order of things, and, supposing the design to be made, arrange the draught to suit it. The easiest way of doing this is to follow the plan shown in Fig. 152, each horizontal space representing a heald instead of the horizontal line, as in the previous arrangement, the dots over the design representing the healds upon which the respective threads are drawn, and the numbers up the side indicating the order or position of the healds. It will thus be seen that the first dot, which is upon the first thread, is also upon the first heald, the rest following consecutively up to eight; the ninth thread is drawn up on the fourth heald. To ascertain the reason for this examine the ninth thread, and it will be found to work in precisely the same order as the fourth thread, consequently, it must be drawn upon the same heald; the tenth thread works the same as the third, and so on. By careful attention to this rule it will be found that very frequently patterns, which on the face of them appear to require a great number of healds, may be very easily worked upon a very small number, by arranging the draught and treading to suit it. I will now take another example to

illustrate another feature of this arrangement. The example already given requires eight healds, and of course the first eight threads of the design are representative of the rest, consequently, in putting this into work, the weaver will raise

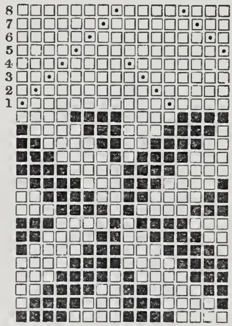


Fig. 152.

and depress his healds according to this portion of the design; but it may very frequently happen that what we may term the representative threads are not altogether in such a compact form as in this case, but scattered at various intervals over the design; in that case the draught must first be ascertained by the method described above, and

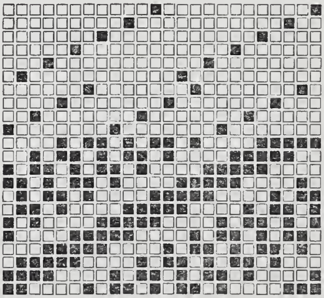


Fig. 153.

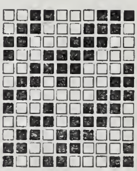


Fig. 153 *a.*

the representative threads of the design copied on a separate piece of paper, to make what is called a working design, for the weaver to peg or arrange for whatever kind of machine it is to be woven upon. Fig, 153 is a

design which will fully illustrate this, the full design being given here as it will be in the cloth, and Fig. 153A is the working design or pegging plan from which the weaver must work, and the draft is placed just over the design.

We may now proceed a little further with our examination of the arrangement of designs, so as to show as fully as possible that some of the most intricate designs are merely combinations of very simple effects, many of which may be woven upon a very small number of healds. With two healds, as has already been pointed

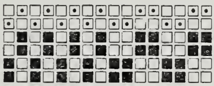


Fig. 154.

Fig. 155.

out, we have not much scope for patterns, except such as are produced by combination of colours, but as we increase the number of healds we increase immensely the number of patterns which may be produced, but even with two only, the variety is much greater than would appear at first sight. We have already a few samples in Figs. 59, 60, and 61. Again, we may carry this much further by

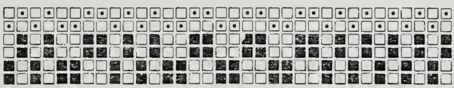


Fig. 156.

working after the manner shown at Fig. 154, combining what is shown at Fig. 155 A and B, so as to produce a stripe pattern. Again, this stripe may be varied to an infinite extent, as is shown in Fig. 156 where varying sizes of stripe are shown, consisting of the two patterns shown at Fig. 155 A and B. Then we come to another question, how to arrange the draught and order of raising the healds to produce those patterns. The simplest and readiest way of doing this is shown at Figs. 154 and 156, as already shown. Instead of drawing horizontal lines to

represent the healds, and numbering the order of the draught upon them, suppose the horizontal spaces immediately over the design, Nos. 1, 2, to represent them ; then the dots in those places show through which heald the thread is drawn. For instance, in Fig. 154 the first thread on the left is marked upon the first horizontal space, thus indicating that that thread is drawn through the first heald ; the second is marked upon the second space, it would therefore be drawn through the second heald ; then, as each alternate thread of the first eight are working exactly alike, they are drawn through the same heald. Coming to the ninth and tenth threads, they are found to be working together and in exactly the same order as the first, therefore they would be both drawn through the first

Fig. 157.

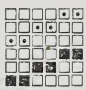


Fig. 158.

Fig. 159.

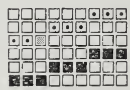


Fig. 160.

heald, the eleventh and twelfth through the second, and so on. The first and second threads are representative of the whole pattern, and therefore indicate the order of working of the two healds as shown at A 155 so each heald would remain up and down alternately for two picks.

If we deal with three healds in the same manner, we shall find that we have more scope, and can produce greater variety of pattern. Figs. 157 and 158 are practically both the same thing, one showing the twill running with the warp and the other with the weft ; in one case three ends and six picks are occupied, and in the other six ends and three picks, but in both cases three healds would be sufficient, as shown by the draughts. Figs. 159 and 160 are also the same thing, and worked on the same

principle as 157 and 158, but with three picks and three ends respectively, instead of two. In Fig. 161 we have a pattern of a different character, but equally applicable to three healds. Again, each of those patterns may be varied, as shown at Figs. 162, 163, and 164, and still only three healds be used. These variations may be carried considerably further without the use of more than three healds. Using four healds the number of patterns which may be

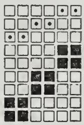


Fig. 161.

produced increases immensely; in fact, we may say there is no limit to the number of patterns, although there is a limit to the number of combinations, or rather to the number of distinct styles of working which may be combined in the same pattern. I have already shown what patterns may be produced upon four ends. Any patterns worked upon four healds must, of necessity, be

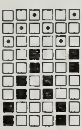


Fig. 162.

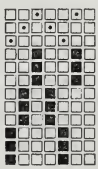


Fig. 163.

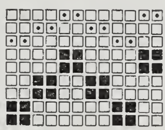


Fig. 164.

a combination of such as can be produced upon four ends, as, for example, the patterns 165, 166, and 167. In the first of these it will be seen there are two kinds of workings combined, in the second three, and in the third two; that is, a plain and a twill pick alternately; in each case the pattern may be worked upon four healds, as shown by the draught, and in each case the first four ends of the pattern to the left represent the order of working for the healds, or what is known as the pegging

plan. One thing must here be remarked. In arranging patterns of this description, care should be taken to have as far as possible the same number of ends upon each heald. If Figs. 165 and 166 be examined, it will be found that each

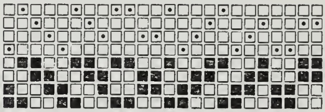


Fig. 165.

heald would have the same number of ends drawn upon it. In Fig. 167 this is not the case, as the first heald would have four ends, the second three, the third two, and the fourth three. Consequently, the first heald would have to be twice

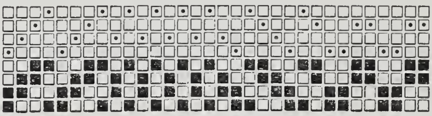


Fig. 166.

as fine as the third, and one-third finer than the second and fourth. This would entail considerable trouble in arranging the healds, and in many cases would cause considerable expense in having to provide special healds for a pattern, which would probably be of no use for any other pattern.

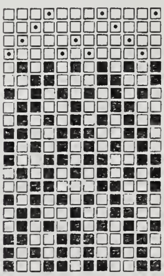


Fig. 167.

This can easily be obviated by arranging the number of ends in each stripe, so as to cause the same number to fall upon each heald. For instance, if we apply the draught, Fig. 168, to the same working as 167, it will only increase

the size of each stripe two ends, and each heald would carry the same number. The stripes may be made either equal or unequal in size, but the above rule should always be observed as far as ever possible.

We may now proceed to examine the subject from another point of view, which will perhaps tend to confirm what has been already said, and at the same time pave the way more fully for what is to follow. In almost every pattern, however intricate it may appear, the styles of

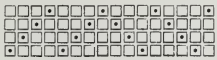


Fig. 168.

working of which it is composed may with a little care be very easily discovered, and it ought to be the first object of the designer when any combination comes before him which at first sight appears new to him, to analyse it, and find out its elements; he can then easily reproduce it, either in the same or in any altered form which his fancy might suggest. By analysing, I wish it to be distinctly understood that I do not mean the common

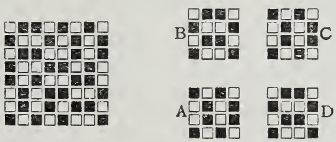


Fig. 169.

practice of picking the cloth to pieces, thread by thread, which is probably the slowest and most uncertain method which can be adopted for getting the pattern of a cloth. Except for beginners, or in extreme cases, such as in milled woollen cloths, where the pattern cannot be easily discerned, not more than very few threads ever need to be picked out of a cloth, and those only to find the basis of the pattern, after which it can be more easily and accurately followed on the face.

If we take, for example the pattern Fig. 169, which at first sight would appear a most difficult pattern to copy or reproduce, especially if a large area had to be covered with it, yet no easier pattern to reproduce could be devised, if proper means be taken to analyse it. If we divide the pattern into four equal parts, as shown at A, B, C, and D,

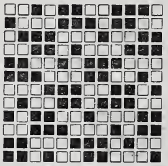
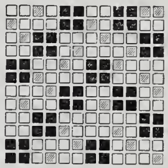


Fig. 170.



A

it will be found that each part is based upon plain cloth, A and C having two picks in one shed, and B and D having two ends working together, so that by bearing this simple fact in mind, the designer may reproduce the pattern with the greatest ease, and combine it with any other working at any moment. Again, the pattern Fig. 170 would be

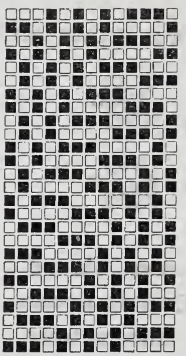


Fig. 171.

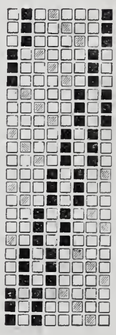
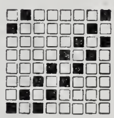


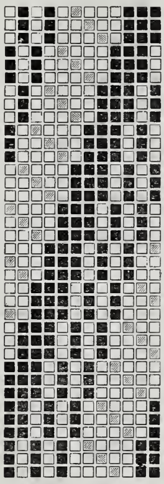
Fig. 172.

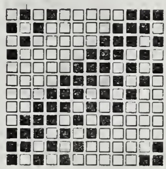


A

a rather difficult pattern to reproduce from memory, unless some order of arrangement were observed, but by following the plan shown at A, where the leading feature of the design is shown in black, and consists of a simple zig-zag figure, and the filling up in shaded squares, which consists

of an irregular arrangement of a four-end satin to suit the figure, the figure may not only be reproduced but varied at will with the greatest ease. Again, in Figs 171, 172, and 173, we have designs which appear distinct in themselves, but each one may easily be reduced to a system. If we take Fig. 171, we shall find one portion of it to consist of a plain cloth, but having two picks in each shed, and the other portion is also based upon plain working, but each pick passing over three and under four ends. Coming to pattern 172, we shall find that the basis of the design





A

Fig. 173.

is that shown at A, each pick being three times repeated; then to fill up the large space which is produced by this elongation, an ordinary four-thread twill is introduced, as shown by the shaded squares; then, as the basis of this design is a twill composed of plain, and weft or warp floating, the whole design is a combination of twill, or simple regular figure, and plain. Again, in Fig. 173 we have a similar combination, but producing a bolder effect, the basis of the patterns being shown at A. Practically, there is no

limit to the variety of patterns which may be produced upon this principle, they are simply elongation of the original twill. We need not necessarily confine ourselves to regular twills for either the base or the filling up of the pattern, but may combine them in any style as fancy may suggest.

In design Fig. 174, we have a combination of a similar

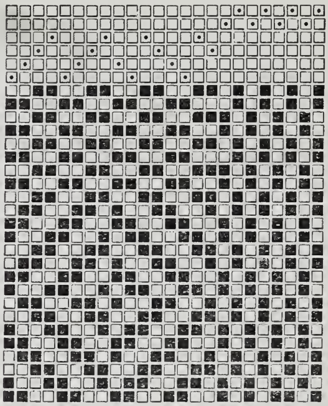


Fig. 174.

character to that in Fig, 166, but in this case the effect would be to produce a check pattern on the face of the piece instead of a stripe; but it is simply a combination of twill and plain working, and is another example of what may be produced upon a small number of healds,

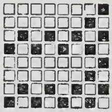


Fig. 175.

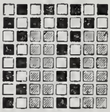


Fig. 176.

the draught which is immediately over it showing that only six healds would be required to weave it, and with a slight modification in the design it might be made upon four healds.

In the same manner the three styles of working, as in Fig. 165, may be combined, or Figs. 169 or 170 combined

with twill, or any two or three styles worked together so as to produce the desired effect. One other style of working now calls for attention. Fig. 175 shows a design which will produce a perfectly plain face on the cloth, but at the same time a line stripe will be visible running the entire length of

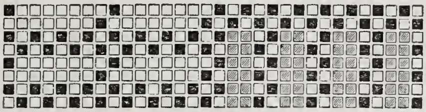


Fig. 177.

the piece. The cause of this will be apparent on examining the design; the first six ends of the pattern are only interwoven with one-half the weft, that is, two picks are woven in quite plain, and the next two pass to the back of the cloth, whereas the seventh and eighth ends are interwoven with every pick, consequently those two ends

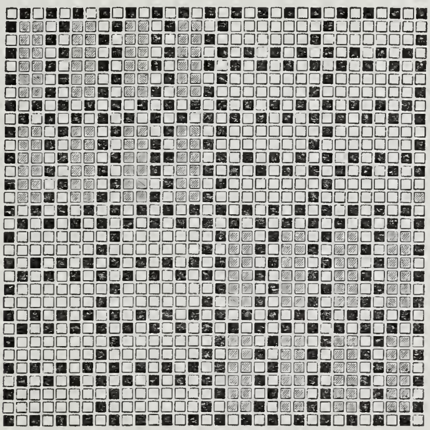


Fig. 178.

having double the quantity of weft interwoven with them, show a clear line throughout the entire length of the piece, and yet the surface of the fabric appears as a perfectly plain cloth. Fig. 176 is a similar arrangement, but in this the *warp* instead of the weft is thrown to the back for six picks, and the seventh and eighth picks are interwoven

with all the warp, consequently the line stripe would run across the piece instead of lengthwise. By a combination of the two an immense variety of patterns may be produced in a very simple manner. Fig. 177 would produce a stripe effect, the first sixteen ends of the pattern being divided by the plain threads longitudinally, and the second half laterally. Again, in Fig. 178 the whole surface of the piece would be divided into squares, each alternate square being again subdivided in opposite directions, the warp and weft predominating alternately; or, we may combine the two with some other style of working, as shown in Fig. 179, where they are combined with twill. It may be advisable again at this point to remind the beginner of what was pointed out in a previous page, viz., that whenever two styles of working are combined in one pattern they should be so arranged as to join without any imperfections being visible at the junction. If Fig. 179 be examined it will be seen that this is done simply by dividing the two plain ends and picks, and placing one on each side of what may be termed the thin portion of the cloth. In any combination it will be easy to find the best means of joining. Following out this principle of working, taking some simple design or designs as a basis, and re-arranging and combining, the designer will find little difficulty in producing an unlimited variety of patterns. All the foregoing are what are commonly known as all-over effects, that is, the design is evenly distributed over the whole surface of the fabric. This certainly represents the great majority of fabrics, but what are known as set or spot figures form no inconsiderable portion, and with them we must now deal.

SPOT FIGURES.

As has been already pointed out, set or spot figures may be produced in a variety of ways; first, by the warp

or weft, or both, which are forming the ground cloth; second, by extra spotting weft; third, by extra spotting warp; or fourth, by a combination of the two latter, using extra spotting warp and weft. A simple example of the first of these is given at Fig. 180, where the spot is formed by the weft, the ground being a perfectly plain cloth. On the back of the cloth a similar spot would be formed by the warp, therefore in this class of spots it is merely a question of leaving down the warp if a weft spot is to be formed on the face, or raising it if a warp spot is to be formed. Fig. 181 is a spot figure, in which

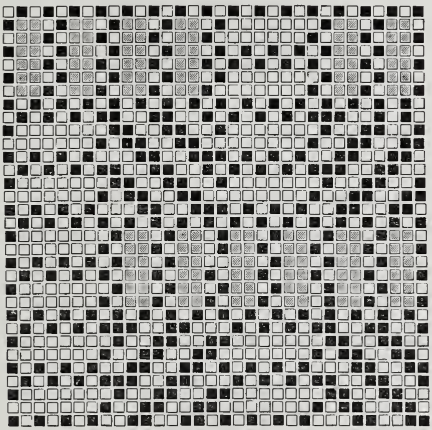


Fig. 179.

both the warp and weft of the ground cloth are made to form part of the figure, the black representing the weft, and the shaded squares the warp. The figures may be placed at any convenient distance apart, and the ground may be plain, twill, or any other working suitable to the nature of the fabric. Whatever may be the working of the ground, it has only to be marked upon paper in addition to the spot, and so reproduced upon the fabric. Then so far as this class of figuring goes little more need be said, because it is merely an adaptation of the style

of working with which we have been dealing, the figures assuming a definite form, and confined within a certain space. But this applies not only to small spots, but also to the more general principles of figuring. Very large and elaborate figures may be produced either with weft or warp, or both; in fact, the whole surface of the fabric may be covered with figuring exactly upon the same

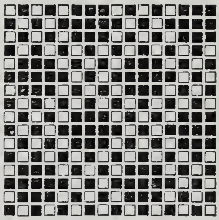


Fig. 180.

principle. When the weft or warp is not forming figures, they may be interweaving, so as to form plain or ground cloth. Then another question arises now. If there be too much figuring on the cloth, and the figure is formed by the ground weft or warp, or both, the distance over which the figure extends, or the number of threads over or under which the weft or warp passes, may represent

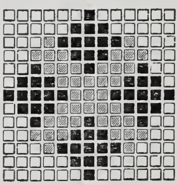


Fig. 181.

so much loose material, and so give a looseness to the fabric which would be seriously detrimental to it. In that case it becomes necessary to introduce what are termed binding threads at certain intervals in the figure. If the design be of a floral character, or simple leaves, this is comparatively easy, for then the binding threads may be

made to form the stems or veins of the figure. Where this is not feasible it may be frequently effected by introducing a little shading in the form of twill or other working, or, where it is absolutely necessary to preserve the flat unbroken appearance of the figure, then the satin working may be resorted to. In all cases the designer must be guided by the nature of his cloth, and the purpose to which it is to be applied, and make his design subservient to these considerations.

Another system is frequently adopted, which is suitable for either spots or more elaborate figuring, that is, allowing the warp and weft to exchange places with each other, and preserving the same working, whether it be twill, satin, or otherwise, both in figure and ground. An example of this is shown at Fig. 182, where the ground is represented as five-thread satin, with the warp predominating, and a portion of the spot also as five-thread satin, but with weft predominating on the face; the other portion of the spot being a five-end twill, for the purpose of producing a kind of shaded effect. The two examples here given, Figs. 181 and 182, would require to be placed at suitable distances apart upon the fabric, to give effect to them. This distance may be varied at will, or to suit the nature of the cloth. The order of arrangement may also be considerably varied, that is, the figures made to assume various positions or placed at varying distances from each other, or we may go away out of the region of mere spot figuring and deal with more elaborate effects; in fact we may figure to as great an extent as we please. It might be as well at this point to call the student's attention to damask weaving, which is merely an extension of the principle of figuring shown in Fig. 182. If he will examine a piece of damask cloth he will find that to whatever extent the figure may be carried, or however large the figures may be on the fabric, there is no looseness, the

fabric is equally firm throughout. This arises from the simple fact that when the figuring takes place, the warp and weft merely change places. If the ground of the fabric is a satin showing a predominance of warp on the face, the figuring is also a satin, but showing a predominance of weft on the face. This class of figuring, or rather this style of working, is a most useful one, more especially when applied to fabrics where firmness

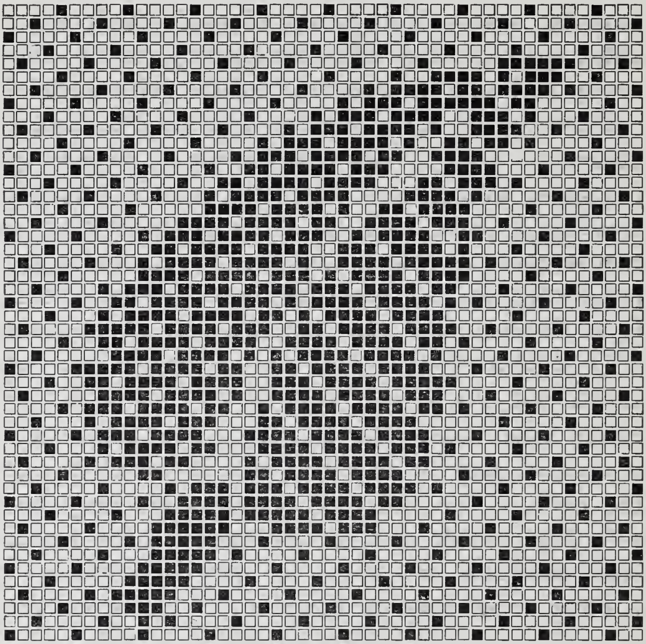


Fig. 182.

of texture must be preserved, because no matter what amount of figure may be introduced the cloth is in no way deteriorated, but preserves its firmness, and, consequently its useful wearing qualities to the fullest extent. This style of working, although as has been shown a most serviceable one, is not of course adapted for every class of fabric, but only in fact for fabrics of a very fine or

heavy character. The ground, being worked generally as a satin, necessitates the introduction of a considerable quantity of material to give the cloth sufficient firmness; it could, therefore, only be used to advantage where a large quantity of fine material is used in the formation of the fabric, or where a very heavy fabric is desired. It would, therefore, remain for the designer to select the style of working which will be most suitable to the nature of the material which he is using. The style and arrangement of his designs must also be governed by similar considerations. But this subject will be more fully dealt with under the head of designing for Jacquards, to which it more properly belongs, the object at present being to point out the various systems of arrangement and combination.

Then these three figures represent the principle of

Fig 183.

spotting or figuring with the same warp and weft as form the ground cloth. Spotting with extra warp or weft, or both, will require a totally different arrangement upon paper to those. We will suppose that it is desired to produce the small spot, Fig. 183, with extra coloured weft upon a perfectly plain fabric; then the arrangement of the design will be as shown at Fig. 184, the picks marked *a* being the spotting picks, and the rest the ground picks, which will be seen to form a plain fabric, the spotting picks passing over sufficient threads to form the desired pattern, as shown by the shaded squares, and then passing to the back of the cloth for a certain distance, and again coming to the face to form the next spot.

Another question now arises in connection with these spots. Very frequently they are woven with healds, and with a small number of healds a great variety of patterns

may be produced, by a careful arrangement of the draughts. For this design eight healds would be required, the draught being shown over the design, the first and second healds being required for the ground cloth, the next three for the first spot, and the last three for the second spot. The working design, or that which shows the order of raising the healds, is given at Fig. 185. But with a similar number of healds, much more extensive and elaborate designs might be produced quite easily. Then in spotting with extra weft, only one thing is required to be observed, that the spotting weft passes over only as

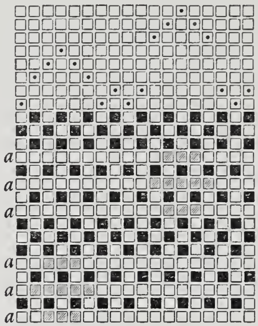


Fig. 184.

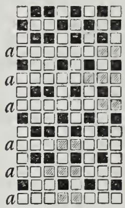


Fig. 185.

many threads as are required to form the pattern, and then goes to the back of the cloth, where it may be dealt with in such manner as may be desirable, either by binding to the cloth or cutting off; the method of dealing with this will be shown at a later period.

In spotting with extra warp, a similar arrangement is required as in spotting with weft. Fig. 186 is the design for a warp spot, the figure being the same as that in Fig. 184. In this case the ground weaves on as in an ordinary plain piece, the spotting warp being drawn through separate healds and raised or depressed as desired, to form the figure. The draught is shown over the design, and the

working plan at Fig. 187. In this case it will be noticed that although the same kind of spot is produced as in Fig. 184, yet only six healds are required to produce the pattern. If the two designs be examined, it will be found that the healds which are used to produce the spot in Fig. 184 have also to assist in forming the ground, whereas in Fig. 186 the spotting healds work only the spotting threads,

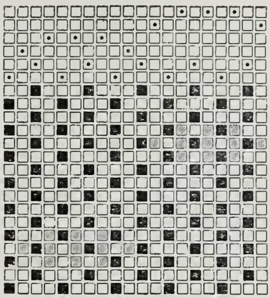


Fig. 186.


Fig. 187.

and take no part in forming the ground, consequently there is more scope for producing a variety of figures upon a small number of healds when the spot is worked in the warp than when it is produced by the weft.

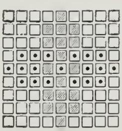


Fig. 188.

We have now only to deal with figures produced by extra warp and weft, or a combination of the two foregoing. Fig. 188 is a design which is intended to be so produced, the shaded squares representing the warp, and the dots the weft. The arrangement of the design for this upon a plain ground is shown at Fig. 189, where the warp and weft spotting are represented as in Fig. 188,

the draught for working upon healds being given immediately over the design, and the working plan at Fig. 190. It will be observed that in this case I have marked clearly the healds which are intended for the ground, those which form the ground under the spot, and those which work the spotting threads only, both in the draught and the working plan, so that the student may be able to follow them more readily.

It will be observed of the arrangement of this draught, that being a combination of the two principles of spotting already dealt with, two sets of extra healds are required, viz., that which works the ground under the spot, and that which works the spotting warp, two healds working the ordinary plain ground as in the previous cases. An examination of the design will make the necessity for this arrangement quite clear. The spotting warp must of necessity have special healds to work it, and the ground threads which come under the weft portion of the spot, although in the actual interweaving working exactly like the rest of the ground, must be so arranged that they can be depressed in the order desired for the spotting weft to pass over; consequently the warp must be drawn through special healds to enable this to be done. In fact, this spot being a combination of the two principles shown at Figs. 184 and 186, the arrangement of working is in every respect a combination of the two. Then, with respect to the figure itself. If Fig. 188 be examined, it will be seen that where the weft and warp cross each other, they are made to interweave as plain cloth; and in Fig. 189, it will be seen that the same arrangement is preserved. This is produced by the simple raising or depressing of the spotting warp when the spotting weft is being thrown in. In fact, the extra warp and weft, at the point where they interweave with each other, form a cloth quite apart from the ground cloth, but this will be

more apparent to the student after reading the next chapter, on double cloth.

There is one apparent discrepancy between the spot as shown at Fig. 188 and Fig. 189. In the former it is represented as occupying nine ends and nine picks; in the latter as occupying eleven each way. In Fig. 188 it will be found that the weft portion extends for three ends on each side beyond the warp portion, and in the same manner the warp extends three picks above and

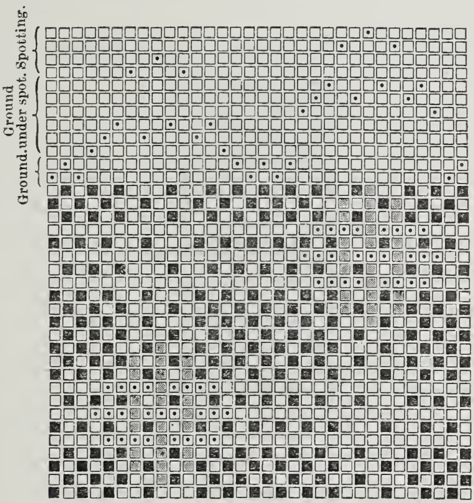


Fig. 189.

below the weft. The same thing occurs in Fig. 189, and it will be observed that between each spotting warp thread one ground thread is introduced, and between each spotting pick one ground pick; and as these are introduced for the purpose of making the ground cloth continuous and perfect, they have no effect upon the size of the figure, consequently the figure must pass over them as though they were extra threads and picks.

There is but one other matter to which the student's

attention need be called in connection with spotting, viz., binding the loose material at the back.

It frequently happens that the spots are so far apart that the loose warp or weft at the back requires to be bound to the cloth, or cut off. Under the head of double cloth this binding will be dealt with fully, so that nothing need be said upon the subject here, more than to call the student's attention to it. Very frequently spot figures are woven by what are known as swivel looms, that is, looms where there are a series of small shuttles for the purpose of weaving in the spots, quite separate and apart

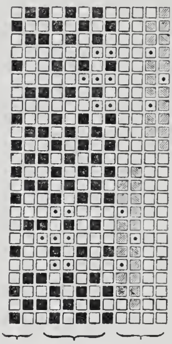


Fig. 190.

from the ground shuttle, and by this means the loose material at the back is entirely obviated, except the single thread, which having completed one figure passes to the next ; but in this case the arrangement of the design will be precisely the same as for ordinary spots, the whole difference being simply the mechanical arrangement of the shuttles.

The few examples given here embrace all the principles of spot weaving, but they are capable of an infinite extension and variety of arrangement ; each of the four systems may be used separately or combined, and the most beautiful and elaborate effects produced.

DOUBLE CLOTH.

Double cloth is a branch of fancy weaving which is not practised generally, being confined to the woollen and carpet manufactures chiefly, and very little used in the cotton, silk, or worsted manufacture, except occasionally in the latter branch for coatings, in which case a woollen back is woven on for the purpose of giving weight and warmth.

Double cloth is for the most part composed of similar fabrics, which are sometimes interwoven at intervals and formed into a diversity of patterns, the two cloths being of different colours, the one colour forming a pattern on the other.

Double cloths are of three kinds, one formed with one warp and having two weft surfaces, the second formed

A B

Fig. 191.

with one weft and having two warp surfaces, and the third being two distinct cloths, as indicated at pages 164 and 165. In all three cases each of the two surfaces may be of different colours and of different patterns, but it is in the latter kind that there is most room for the exercise of the ingenuity of the designer in producing patterns.

The first kind is usually used for woollen goods upon cotton warps, the second for silk faces with cotton or other wefts. By this means the cotton warp may be entirely hid, and two woollen or other surfaces presented, which may be of different colours, or one of solid colour and the other striped. Fig. 191 is a plan for a double cloth of this kind, the dark squares are the face working and the shaded ones

the back, the patterns A and B representing the face and back patterns respectively. In the face working it will be observed that only every fourth thread is raised to form

Fig. 192.

the upper portion of the shed while the pick is put in, thus allowing every fourth end only to be interwoven, and for the back only every fourth thread is left down to form

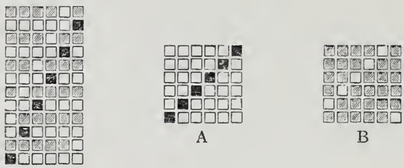


Fig. 193.

the lower portion of the shed while the pick goes in, thus each side of the piece will be a *fac-simile* of the other so far as pattern goes, but they may be of different colours by

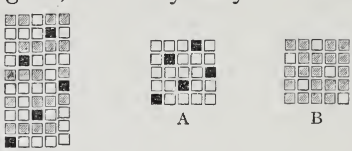


Fig. 194.

using differently coloured wefts. Fig. 47, page 165, shows a section of this species of double cloth. Fig. 192 is a similar

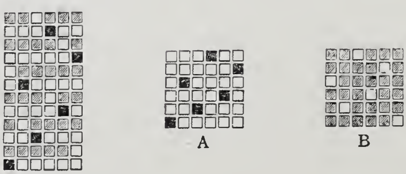
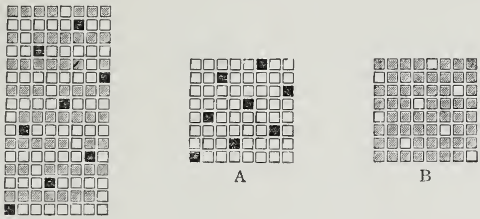


Fig. 195.

arrangement with a five-thread twill, A being the face and B the back pattern, and Fig. 193 is a six-thread twill on

the same principle. In the same manner any twill may be worked out. Fig. 194 represents a five-thread sateen, Fig. 195 a six-thread, and Fig. 196 an eight-thread sateen, all on the same principle of double face cloth. In the same manner twill and satin may be combined, or a variety of patterns produced; or the system may be carried still further, and figures produced by bringing the back weft



A B

Fig. 196.

to the face, or taking the face weft to the back, as shown in the section, Fig. 197, so that if the face cloth be white and the back black, a black figure would be produced upon white ground, and a white figure on black ground

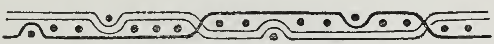


Fig. 197.

on the other side. One thing must be carefully observed in the arrangement of designs for cloths of this description, viz., that a face and back pick successively must not be bound by the same warp thread, otherwise, if the two sides

Fig. 198. A B

of the cloth are of different colours, one will be liable to show through the other and produce a sort of spotty appearance.

The second kind of double is simply the first inverted, the warp taking the place of the weft, and the weft taking the place of the warp. Fig. 198 is a four-thread twill

arranged for double warp face, A and B being the face and back respectively, as in the previous arrangement, and Figs. 199 and 200 are five-thread and eight-thread satins on the same principle.

Both these systems of making double cloths are especially valuable in making heavy goods where the pattern at the back is intended to serve as a lining only

Fig. 199. A B

to the face; and when the face pattern is a fancy one and the back as near plain as possible. Whenever such is the case there is no alteration in the principle of arranging the design, only a proper regard must be paid to the binding the back to the face, so as not to interfere with the pattern on the face cloth. In such cases proper regard must be paid to the relation which the two patterns bear to each other—face and back respectively—as well

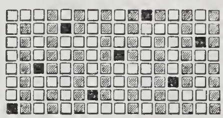
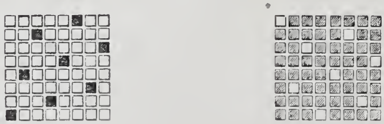


Fig. 200.



A B

as to the relations of the two cloths in regard to fineness, and a position for the binding of the back weft into the cloth must be found in strict accord with the rules which will be laid down for binding two separate cloths.

The third and most generally used double cloth consists as before mentioned, of two separate cloths, which may be stitched or bound together in the process of

weaving, or kept separate if desired. For the purpose of making it as clear as possible to the reader, I shall in all cases treat the two cloths as being kept separate, and afterwards explain the method of stitching or binding them together.

The simplest form of double cloth consists of two equal plain cloths, that is, two cloths having the same number of threads per inch, and of the same quality and thickness, both woven quite plain. Take for example what may be called tubular weaving, such as hose or sacking, where the two cloths are kept separate, and joined

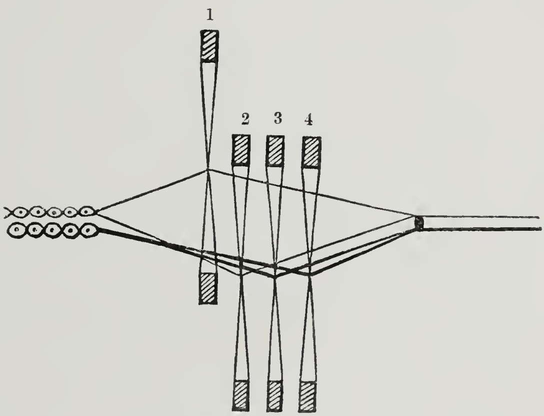


Fig. 201.

together by the weft passing from one cloth to the other at what would otherwise be the selvage, thus forming an open tube. To effect this the weft passes through the warp of the upper cloth, and in the return pick through the warp of the lower cloth, making the junction of the two cloths, as stated, at the selvages, and Figs. 201 and 202 show clearly the mode of working to produce this result. In Fig. 201 the shed is represented as being open to receive the pick for the upper cloth, and it will be observed that one half of the warp of the upper cloth is

raised and the other half is depressed, as well as the whole of the warp of the lower cloth. The pick having been thrown in, the shed is then opened as in Fig. 202, where it is shown as being open to receive the pick for the lower cloth. Here it will be observed that the reverse of what occurs in Fig. 201 takes place; the whole of the warp of the face or upper cloth is raised and one half of the lower cloth, the other half of the lower cloth being depressed. The one rule to be observed is this, that when the pick goes into the face or upper cloth, only such portion of the warp of that cloth as is necessary to form the pattern must

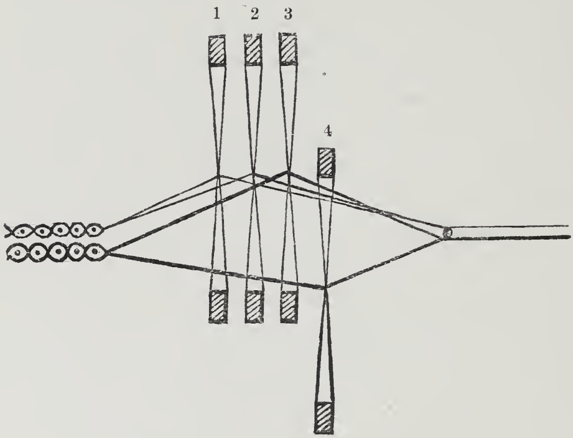


Fig. 202.

be raised, the other portion being depressed along with the whole of the warp of the back cloth; and when the pick goes into the back cloth the whole of the warp of the face cloth must be raised, and such portion of the warp of the lower cloth as is necessary to form the pattern, the remainder of the back cloth warp being depressed. On careful examination of Figs. 201 and 202 the reader will at once see that this is done, and also the necessity for doing it, so that the warp of one cloth shall never interfere with the pick of the other cloth, else the

two cloths would be bound together instead of being separate.

In the example given at Figs. 201 and 202 the healds are indicated by the figures 1, 2, 3, 4, Nos. 1 and 2 being the healds which work the face cloth, and 3 and 4 those which work the back cloth. It will now be necessary to show the student how to arrange the pattern upon paper, both for draught and for working design, or, as it is generally termed, pegging. Fig. 203 shows the draught; 1, 2, 3,

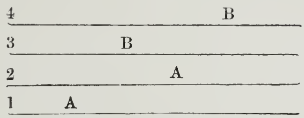


Fig. 203.

and 4 are the healds, and as before stated 1 and 2 are for the face cloth, consequently the warp threads A A are drawn upon 1 and 2 alternately; 3 and 4 being for the back cloth the warp threads B B are drawn alternately upon them, this being repeated to the full width of the piece. The order of working is shown at Fig. 204; A A are the face cloth picks when one heald out of the four only is raised, as indicated by the black dots, and B B are the back cloth picks when three healds out of the four are raised, viz.,

Fig. 204.

both the face healds which are indicated by the dots, and one of the back healds indicated by the shaded square. It is not the general practice with designers to make the three kinds of marks, but it is very much better to do so, or to work in three colours, which is still better; it is then so much easier to follow the pattern which is being made upon each cloth, and the marks which indicate the rising of the face warp when the back pick is being

put in are easily distinguishable from those forming the pattern, and so prevent confusion.

In this example it is arranged that the face healds are together and the back ones together, and are thus treated as separate sets; but this is not always the case, though it is much simpler when it can be so. It sometimes happens that there are healds which have been working some other cloth that it is desirable to utilize, or it may be wished to draw the warp through the healds so that they can after-

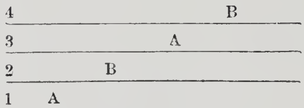


Fig. 205.

wards be used for some other purpose. Then we will suppose that they are drawn straight over from front to back as in Fig. 205; A A are the face ends and B B the back ends. It will now be observed that A A, instead of being drawn upon 1 and 2 healds, are drawn upon 1 and 3, and B B upon 2 and 4; the process of weaving is precisely the same as before, the only difference being that the second and third healds have changed places. The working plan, Fig. 206, will, on comparison with the working plan in the

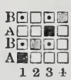


Fig. 206.

previous case, Fig. 204, clearly demonstrate this, the picks occupying the same position, but the healds 2 and 3 having changed places.

This arrangement shows the necessity for observing the rule laid down in a previous page, viz., that, in making working designs, the arrangement of the warp threads and the order of picking must be carefully followed. The best and easiest way in making double cloths is to put upon the design paper the pattern which is to form the face cloth,

of course observing all the while that you touch nothing but the threads and picks of which that cloth is to be composed; do the same with the back cloth, and then put in the lifting marks, all three being in different colours or in different marks.

So far I have only treated the matter as if we were weaving two cloths of the same colour, or a sack, but it will be readily understood that if, instead of using only one shuttle and allowing the same weft to enter both cloths, two shuttles are used, each carrying differently coloured wefts, and the two warps of corresponding colours, then by keeping each weft to its own warp the two cloths would be of different colours; or, by using only one shuttle and

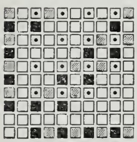


Fig. 207.

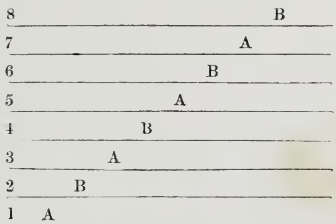


Fig. 208.

allowing two picks to be woven into each cloth alternately, a cloth would be produced which would open out to double the width which it occupied in the loom, because the connection of the two cloths would occur at one edge only, the other edge being left entirely free and open.

I have dwelt at considerable length and minutely described the details of this class of cloth, not only because in the making of double plain cloth the whole principle of double cloth making is involved, but because I believe by careful attention, until a thorough mastery of double cloth making is obtained, the student acquires a habit of following the pattern upon the rule mentioned above, which he will find of incalculable service to him

in arranging patterns for other kinds of cloth, and that it will, in fact, lay bare before him the whole system of weaving to a far greater extent than could possibly be the case with the study of any other branch of weaving.

Having thus fully dealt with double plain cloth, we will now proceed to the consideration of some other makes and combinations. Fig. 207 is a design for a double cashmere twill cloth, with the draught as shown at Fig. 208, A A A A are the face threads and B B B B are the back threads, consequently the healds 1, 3, 5 and 7 are the four healds upon which the face cloth is worked, and 2, 4, 6 and 8 are those upon which the back cloth is worked, the dark and shaded spaces at the bottom and up the side of the

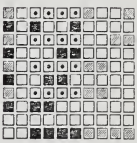


Fig. 209.

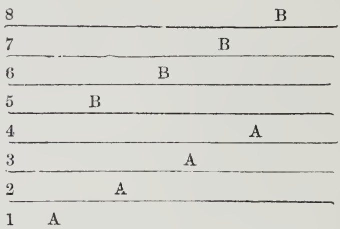


Fig. 210.

design also indicating which are face and back ends and picks. In the design the pattern for the face cloth is shown by the black squares, the back cloth by the shaded, and the dots are to raise the face warp when the back pick goes in. Fig. 209 shows the working design with the draught, as given at Fig. 210, that is, with the face and back healds treated as two sets. This will be very readily understood after carefully studying the plans for the plain cloth.

There is one feature in twilling double cloths to which I must call the attention of the beginner. In the example just given the twills for both the face and back run in the same direction on the paper, but when put into the cloth

they would run in opposite directions, because the upper surface of the lower cloth being next the upper cloth the under surface becomes the face of that cloth, and when

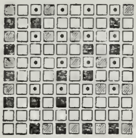


Fig. 211.

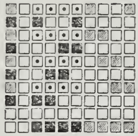


Fig. 212.

turned over presents the twill running in the contrary direction to that presented by the face cloth ; and in making twills the importance of the twill running in a

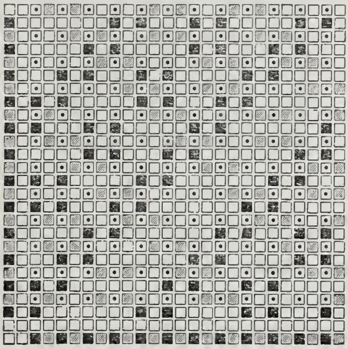
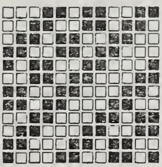


Fig. 213.

particular direction, according to the twist of the yarn, has been fully shown at page 175; then to prevent this occurring, the pattern must be put upon paper with the



Pattern of 213.

two twills running in contrary directions, the draught remaining the same as before. Fig. 211 shows a design for a twill arranged in this manner on the same draught

as Fig. 208, and Fig. 212 is the same thing on the draught of Fig. 210. So far we have only dealt with plain and cashmere twill, but it will be easily understood that any pattern may be woven upon the same principle. Not only may any pattern be woven upon both cloths, but each cloth may be different. Figs. 213 to 216 are a few examples of what may be done; Figs. 213 and 214 having

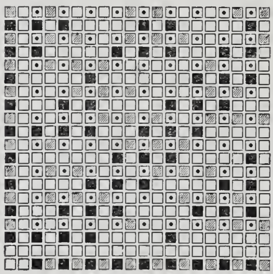
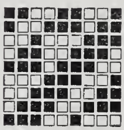


Fig. 214.

both cloths of the same pattern, and Figs. 215 and 216 having the two cloths different. The whole of these designs are arranged upon the principle of draughting shown at Fig. 208, that is, the face and back healds being alternate.

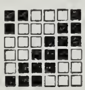


Pattern of 214.

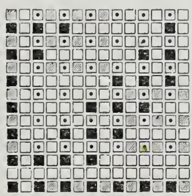
We have up to now supposed the two cloths to be equal, and so made that the cloth would be reversible; but it very frequently happens that the two cloths are not equal, that a fine face cloth may be desired with a coarse cloth woven to the back of it for the purpose of giving weight. In this case the face cloth very often stands in relation to the back cloth of two threads to one, a pattern

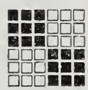
being woven on the face and the back being perfectly plain. For this class of weaving, the healds upon which the warps for each cloth are drawn are treated as two sets, as in Fig, 210, and not intermixed as in Fig. 204. Fig. 217 shows the draught for a cashmere twill face and a plain back, the proportion being two threads face and one back, both in the warp and weft, and Fig. 218 is the working design for it. It will be observed that the working is precisely the same in principle as when the cloths are equal, the only difference being the relative number of threads in each cloth. Fig. 219 is another pattern arranged upon the same principle, that is, with all the healds for the face cloth together and those for the back cloth together.

Again, in Figs. 220 and 221 we have arrangements



Face cloth.





Back cloth.

Fig. 215.

upon the principle of the face and backing healds being intermixed, as shown in the draught, Fig. 222, A representing the face, and B the back threads as before. A very little attention to these examples will convince the student that the principle of working is the same, in whatever proportion the two cloths may be to each other.

Now with regard to stitching the two cloths together, which is quite as important as the arrangement of the design. The stitching or binding is, of course, as implied, for the purpose of securing the two cloths together in such a manner as to make them appear as one cloth. Considerable care is required to do this successfully, especially in

some makes of cloth, when the two sides are of different colours, the one colour being liable to show through the

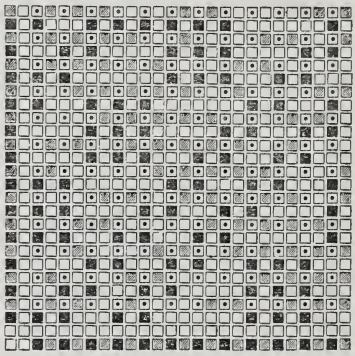
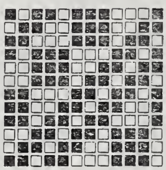
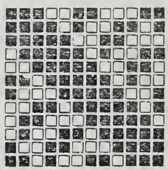


Fig. 216.

other ; or if the two cloths are very thick an effect may be produced which gives the cloth an appearance as if it



Face cloth.



Back cloth.

was embossed. Sometimes this latter is done purposely to produce a pattern, as in the cloth known as the matelasse, where the two cloths are bound together, and

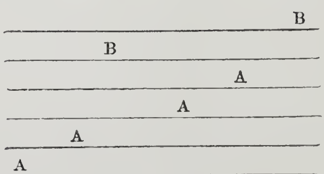


Fig. 217.

the space between them filled with thick soft yarn to give a soft wadded effect ; the same thing is also done in quilts.

To bind two cloths together so as not to be visible the best and easiest way is to take a pick of one cloth and a warp thread of the other, at some point of the pattern where both happen to be working in the same

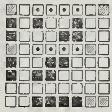
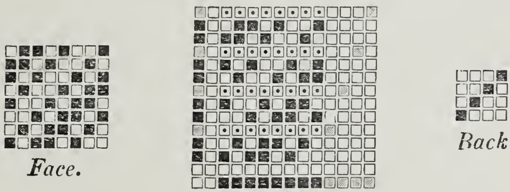


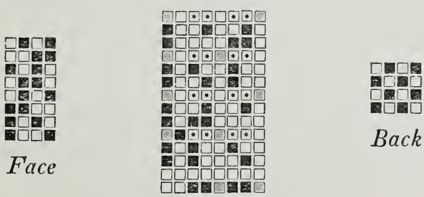
Fig. 218.

space between the two cloths, and interweave them, as shown in Fig. 223, where the two cloths are bound together at point A; and on examination it will be found that the



Face. *Fig.* 219. *Back*

warp on one side and the weft on the other effectually hide the stitching threads. But supposing they were stitched together as shown at Fig. 224, it is pretty certain



Face *Fig.* 220. *Back*

that the stitching threads would show on both sides, and if the cloths were thick, the embossed effect mentioned above would also be produced, because the stitching thread actually passes through from the surface of one cloth direct to the surface of the other, consequently at this

point the two cloths actually become one, while between the stitching threads they remain separate and distinct. The result of this kind of stitching is more marked in woollen cloths, which have to undergo the process of

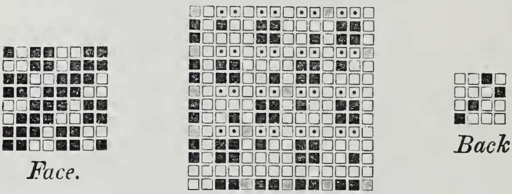


Fig. 221.

milling. The method of stitching is, as indicated in the sections given, to raise a warp thread of the back cloth when a face pick is being put in, or *vice versa*, the distance apart of the stitching threads being regulated as the cloths

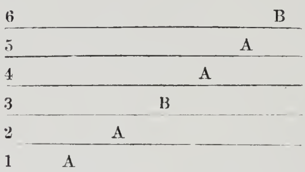


Fig. 222.

are required to be closely bound together or otherwise. If they are to be bound closely, or if the pattern is a large one on a great number of healds, one of the ordinary healds may be raised or depressed for the purpose of

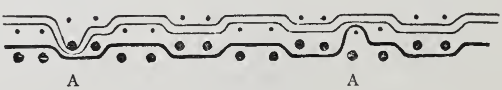


Fig. 223.

stitching, but if they are not required to be closely bound, and the pattern is a small one, then special stitching healds are put on. This heald represents the regular heald upon which the thread selected for stitching would otherwise be drawn, and works all the way through with

that heald, except for the stitching pick, when it is raised or depressed as desired. For the purpose of illustrating this I will refer the reader to Fig. 225, where, supposing the two cloths to be equal, a stitching heald is introduced; the draught follows in regular order until the stitching point is arrived at; then the thread which has been selected for stitching, instead of being drawn upon the third heald,

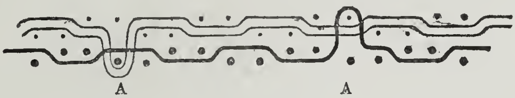


Fig. 224.

as it otherwise would be, is drawn upon the stitching heald. It is then very evident that this stitching heald must work exactly as No. 3 works—else the pattern will be broken—until the stitching pick is arrived at, this pick of course forming a portion of the contrary cloth to the one the stitching thread belongs to. The stitching heald is then raised or depressed, and the binding is effected without in any way interfering with the pattern upon

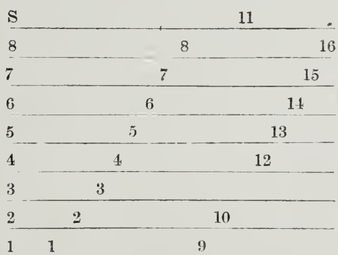


Fig. 225.

either cloth. If desired two or more stitching healds may be used instead of one, so as to avoid the stitching running in straight lines. When cloths are figured by bringing one cloth through the other, no necessity exists for stitching, as the figuring itself is sufficient to bind the cloths together. This will be dealt with further on when dealing with Jacquard figures.

JACQUARD FIGURES.

It is now necessary to deal with Figure Weaving on Jacquard machines. Hitherto all the figures and combinations have been dealt with and arranged for healds; but, as before explained, by the use of healds only limited patterns can be produced, although by ingenuity in the arrangement of the draughting and treading, considerably greater diversity may be produced than would appear possible at first sight, but the figures will of a necessity be of a stiff character, consequently the Jacquard machine becomes necessary.

The Jacquard machine having been described in a previous chapter, it now remains to explain the arrangement of the designs for it, and in many respects this is a much simpler process than the arrangement of designs for healds. For instance, there are no cross draughts to contend with; the whole of the harness being a straight draught from beginning to end, the treatment of the design is just the same as if it were being made for the number of healds which the Jacquard represents; a three hundred and four Jacquard representing that number of threads in what is termed a division of the harness, the pattern must be made to occupy that number of threads on the paper, or such smaller number as will divide a given number of times in three hundred and four, otherwise some of the hooks in the machine will have to remain idle, and the harness threads attached to them must not in that case have any warp drawn through them. The same thing of course also applies to every other size of machine, whether two hundred, four hundred, or six hundred. Then the first question which requires to be dealt with is what is termed

casting out, or in other words, where the pattern cannot be adapted to the harness, the harness must be adapted to the pattern.

I will endeavour to give illustrations of every form of casting out, and the causes which give rise to it, for casting out has frequently to be done for other reasons, but the illustrations in this branch will have to be of a somewhat limited character. A full design for any Jacquard machine would be too large for this work, but those which are given will I trust be of such a nature as to convey fully to the reader a knowledge of the system, and enable him to understand not only the theory but also the practice of designing for Jacquards.

I will begin as I have done in the previous classes by

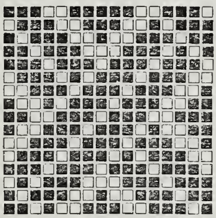


Fig. 226.

giving examples of the simplest possible description. We will suppose that the designs are to be made for a three hundred and four Jacquard (which is the machine regularly used in the Bradford worsted trade). The machine contains thirty-eight rows of hooks, eight in each row. The design paper is ruled to correspond with this, viz., thirty-eight long squares, each containing eight small ones, which represent the warp threads, and usually thirty squares of eight each in the weft way, but of course so far as the weft way of the design goes the number of squares is a matter of no moment, because the pattern may be made to go any length. The number of squares on a sheet is simply a matter of convenience as to size, &c.

Take a given pattern, Fig. 226, it is desired to arrange this pattern to be woven upon a Jacquard of the above extent. The first thing to examine is the number of times this pattern will repeat upon three hundred and four

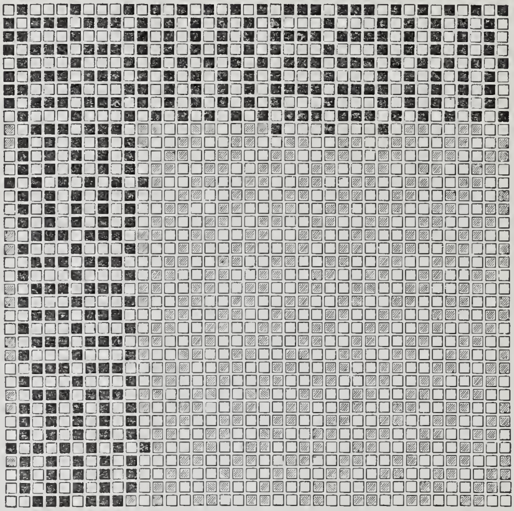


Fig. 227.

threads, or, in other words, the pattern takes sixteen threads, 304 ÷ 16 = 19, so the pattern must be repeated nineteen times across the paper; or if the card cutter is expert at his work the actual repetition upon paper is not

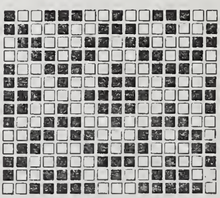


Fig. 228.

necessary, he will read it the requisite number of times upon the card. Take again the design Fig. 227, which occupies thirty-eight threads, 304 ÷ 38 = 8, the pattern must be repeated eight times; but it must be understood

that although the pattern must be repeated a number of times to make up the number represented by the Jacquard it is not necessary that it should be repeated in the weft way. The number of threads occupied by the pattern in the weft way indicates the number of cards that will be

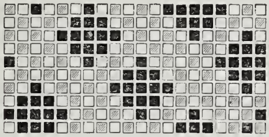


Fig. 229.

required to weave the pattern (this design might also be woven upon healds by reducing the draught). Thus in the two examples given the number of cards required would be respectively sixteen and thirty-eight. In both these cases the number of weft picks which the design occupies

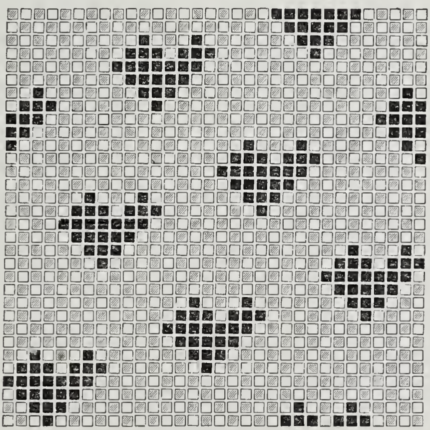


Fig. 230.

is the same as the warp threads, but this is not always the case. At all times attention must first be paid to the number of warp threads being such as will divide in the number of the machine. Fig. 228 is an example of this. The number of warp threads is such that it will divide,

thus 304 ÷ 8 = 38, but the number of weft picks will not. Yet on examination it will be found that the pattern will meet on all sides, and would make a continuous pattern all over the piece. Figs. 226 to 228 are therefore all examples of designs upon such a number of threads as will divide evenly in 304.

Two of these are examples of stiff set figures or spots, two of the spots making a complete design, by simply being set across each other, or alternated; but another practice prevails of so arranging the spots that they shall appear to be more scattered over the surface of the cloth. To effect this the spots are arranged after the order of a satin. Fig. 229 is an example of a figure arranged in the order of a five-thread satin. Take the number of threads which the five

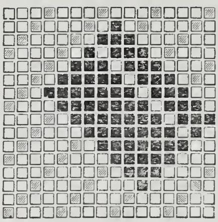


Fig. 231.

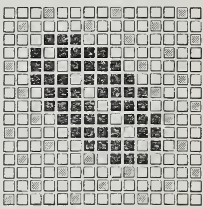


Fig. 232.

spots are to occupy, divide them equally into five, or as near equally as possible; number these spaces in the order of a five-thread satin, and place the spots in order upon the spaces as they are numbered. Fig. 230 is an example of this system of arrangement, in the order of an eight-thread satin.

In these examples the figures are made upon plain grounds, but upon twilled, or any other ground, the system of arrangement is precisely the same, the only difference being made by painting the ground pattern upon the design. Fig. 231 is an example of twilled ground. Fig. 232 is an example of a sateen ground. Of course it must be understood that whatever the nature of the ground the

pattern must be so arranged that not only will the figure meet all round and make a continuous pattern, but the ground must also do the same. In both these instances only one spot is given, as the complete arrangement would occupy too much space.

It may occur to the beginner, that in the arrangement of a design for a spot figure it will be difficult to determine at first sight at what distance to place the figure apart upon the paper, or if the same spots have been worked out upon one arrangement, and it is desired to alter the arrangement, as say from a five to an eight-thread satin order, it will be difficult to preserve the same distance apart. This is not so difficult as may appear. Suppose in the first place it is desired to arrange a new design, and the order of arrangement is to be a satin. To make the matter as clear as possible, I will further suppose that the design has been already arranged with two spots, for the purpose of determining the distance at which they may be placed apart; and that the whole area occupied by the two spots and the ground surrounding them consists of eight ends and eight picks, that is apparently an allowance of four ends and four picks for each spot; and consequently it would appear that if there are to be five spots instead of two, twenty ends and twenty picks would be required. We will see what is the case. Eight ends and eight picks give on the design paper an area occupying sixty-four small squares. (For this purpose the small square may be made the unit of measurement.) We have therefore thirty-two small squares allotted to each figure, that is—for the spot and the ground surrounding it. If we take the twenty ends and twenty picks we shall have $20 \times 20 = 400$ small squares; this divided amongst five spots gives $\frac{400}{5} = 80$ small squares allotted to each spot. Consequently the area in this case would be two and a half times that of the two spots on eight by eight.

If we were putting eight spots and were to adopt the

four picks and four ends for each spot we should have thirty-two picks and thirty-two ends, then 32×32 would give us 1024 small squares, this divided amongst eight spots would give us $\frac{1024}{8} = 128$ small squares each.

Then to find the proper number of ends and picks which may be used in the arrangement of a given number of spots to occupy a given area, or an area similar to another given arrangement, we must adopt another method. Taking again the two spots upon eight ends and eight picks, we find the area for each spot to be thirty-two small squares. Multiply the number of small squares for each spot by the number of spots; that will give us the total number of small squares which must be used. Then extract the square root of that, and we shall have the number of ends and picks required, or in other words we shall have one side of the square in which the number of spots which we are to use must be placed. Thus, suppose we require to use five spots, $32 \times 5 = 160$, the number of small squares to be used, and the square root of 160 is over twelve but not quite thirteen, and as we cannot use any but full numbers we should have to use thirteen ends and thirteen picks. Again, supposing it were eight spots we required to use, then $32 \times 8 = 256$ small squares, and the square root of 256 is sixteen, consequently if we put eight spots upon sixteen ends and sixteen picks in the order of a satin, exactly the same area will be occupied by each spot as if we had two spots upon eight ends and eight picks, and the arrangement will be much better. It will invariably be found that for eight spots exactly the same area can be found as for two spots, and the number of ends occupied will almost as invariably suit the Jacquard, whereas for five spots the area cannot be exact, and the number of ends occupied will not be suitable for the Jacquard.

If the ends and picks differ in number in the arrangement of two spots, one of two courses may be adopted,

either work the square of each side separately, or get the total area, extract the square root, and find the length of each side by proportion; both methods will obtain the same result. Fig. 180, page 210, will be a good example for the student to work out as an illustration.

The examples given here are all for figures formed

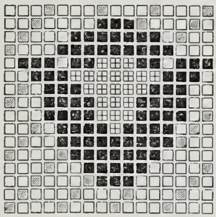


Fig. 233.

with the weft, which constitutes the ground cloth. Fig. 233 is a pattern in which the figure is formed by both warp and weft upon a twilled ground, the portion which has a cross in the square being the warp figure. This principle of figuring may be applied also to any of the other grounds, or the figures may be made entirely of warp, and no weft shown, or the pattern may be formed entirely with warp

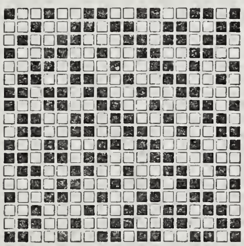
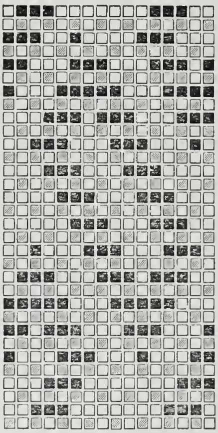


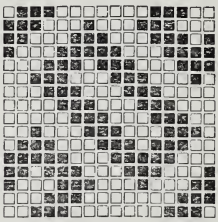
Fig. 234.

and weft figure, all over the piece, and no ground discernable, as Fig. 234.

Then another kind of figure presents itself which may be said to be made on the double cloth principle to some extent. This consists of a solid, perfectly plain, twilled, or other make of cloth, and upon this a figure is formed

by a warp or weft of a different colour. Fig. 235 is an example, the shaded squares represent a perfectly plain ground, and the black squares the figure, which is formed with a separate colour (A being the design shown separately), the order of weaving being one pick of the ground cloth, and one of the figuring. In this class of weaving it will be observed that the pattern is formed by the figuring weft passing alternately to the face and back, the point at which it changes from face to back, and *vice versa*, being determined by the form of the figure. Fig. 236 is





A

Fig. 235.

an example upon a twilled ground (A being the figure, and B the ground pattern). The same principle also applies to patterns made with the warp. Instead of weft being thrown in to form the figure, warp threads of the colour desired are drawn through the desired number of figuring healds alternately with the ground warp, the latter being drawn upon two or more healds to weave the ground, if they are to be woven in healds; or if in a harness the ground and the coloured warp threads are drawn alternately all over the harness, and the design

arranged accordingly, as shown in Fig. 237. which would produce a simple diagonal pattern, as shown at A.

Instead of the figures being made all over the piece, they may be made to run in stripes, crossovers, or in the form of checks, the longitudinal stripes being formed by the warp, and the transverse by the weft.

Small spot figures are also worked upon the same principle. The difference between working spot figures and those just mentioned is mainly that, whereas in the patterns mentioned above the whole of the figuring material

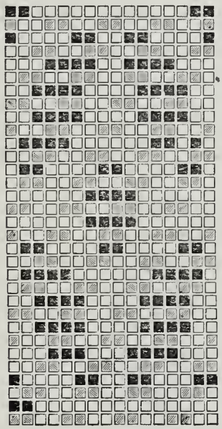
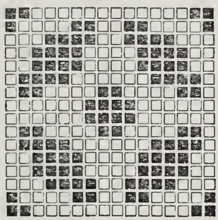


Fig. 236.



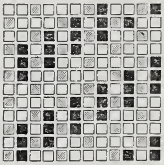
A

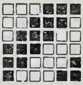
B

is worked loose on one or other side of the cloth; in small spots the figuring material, when not forming the pattern on the face, is thrown to the back—if the cloth is a light one—loosely, and afterwards cut off, but if the cloth is sufficiently thick to allow of its being worked in at the back, without showing through to the face, it is so worked in.

Illustrations without number might be given of this class of figuring. For instance, the spotting warp and the spotting weft may be of different colours, and each form

separate spots, or portions of the same spot; they may be of different shades of the same colour and both be worked into the same figure so as to produce shaded effects, or in such a multiplicity of other ways that a whole volume of illustrations might be given without exhausting the





A

Fig. 237.

subject. The reader has only to walk through a fancy goods establishment to be at once convinced of this.

We now come to the consideration of figures upon double cloths, formed by bringing one through to the face of the other. The method of making double-faced cloths

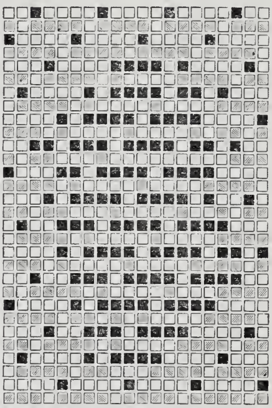


Fig. 238.

upon one warp has been pointed out at page 220, as well as the suggestion that figures may be very easily produced by using two colours of weft, one for each side, and at certain intervals bringing the weft from the back to the face, and taking the face weft to the back. Fig. 238 shows

the way to do this. It will be observed that the face pick when it comes to the figure passes to the back, and *vice versa*. Fig. 239 is an example of figure also of this kind of cloth, the figure taking the form of a diagonal.

Then with reference to figuring with two separate cloths at page 223, the system of making double cloths has been fully pointed out, and applies also to harness or jacquard figures; but in harnesses the warps for the two

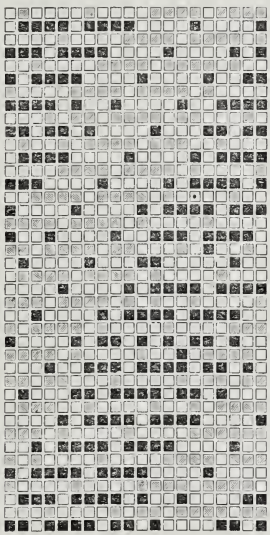


Fig. 239.

cloths must be drawn alternately, as shown at Fig. 205, page 208, and the design arranged accordingly.

Until some amount of dexterity has been acquired it is best for the student to arrange his patterns upon paper, as if they were for single cloth, and then put them on together for the double cloth, because every alternate end belonging to separate cloths, the design will appear to occupy double the amount of space upon paper which it ought to do, in addition to which the beginner is very

liable to get his dots or crosses upon the wrong lines. As pointed out at pages 223 to 226, the formation of double cloth is produced by the warp being divided into two portions, which are kept and worked separately; while the weft is being passed through one the other is kept apart from it. This is arranged upon the design by putting dots to raise the whole of the warp belonging to the face while the pick is being put in the back cloth, &c. As this is the principle upon which the two cloths are kept separate, it is also the principle upon which figures are made; the fact is that no matter what the figure is, whether large or small, the two cloths throughout retain their individuality, whether plain, twilled, or otherwise.

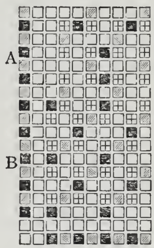


Fig. 240.

To illustrate this we will turn to Fig. 240, which, supposing the two cloths are black and white respectively, will produce a black and white stripe alternately across the piece from side to side, A being the white stripe and B the black stripe. Now, as to the cause of this change of colour, for at a glance there appears no difference between the arrangement of A and B, yet there is a difference, and one of a very important nature. If we examine the stripe B we shall find the lifting marks, which are represented by a ⊞ as we may term them, and which are intended to lift the face warp up while the back pick is put in, are placed upon the second pick, and lift the first thread. The first thread and the first pick are supposed to be black, the second thread

and the second pick are white, consequently the black threads being lifted when the white picks goes in will bring the black cloth to the face, and the white to the back, then this accounts for the first stripe being black. If we examine the second stripe we shall find that the reverse is the case, viz., the lifting mark is on the first pick and the second thread, consequently the white is lifted when the black pick goes in, thus bringing the white cloth to the face, and in this way making alternate black and white stripes. The stripes it will be perceived, may be made any size, by weaving the length required before changing the lifting mark.

From the foregoing the reader will have very little difficulty in following through, step by step, the various

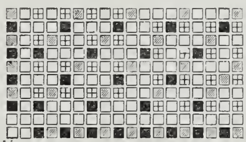


Fig. 241.

stages of double cloth figuring, and understanding easily the principles upon which they are worked. We will now suppose that instead of the stripes being transverse they are intended to be longitudinal; the same principle as to the lifting marks applies as in the last case; in fact, all throughout double cloth figuring this is the one system of working, and in whatever form it may be put the real work cannot be done in any other manner. The difference between this form of stripe and the last is, that in the last case the weft pick traversed the whole width of the piece on one side, whether face or back of the cloth, while the warp threads changed from face to back as required to form the stripe; in the present case the warp threads traverse the full length of the piece, on one or other side of

the cloth, while the weft pick passes from face to back as required. Fig. 241 is a design for a stripe of this kind. The portion of the design A, it will be observed, has the lifting marks upon the first pick and the second thread, thus bringing the white cloth to the face (supposing, as in the previous case, that the first thread and first pick are black, the second thread and second pick are white, the principle which I shall observe throughout these examples) ; on B, the lifting marks are upon the first thread and second pick, bringing the black cloth to the face, consequently, as explained, the weft will work on the face, in one portion of the cloth, and on the back in another portion, and this is repeated throughout the entire length of the cloth.

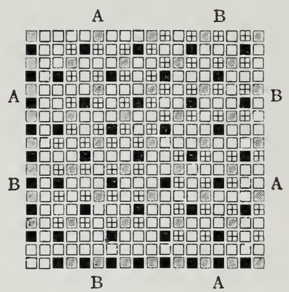


Fig. 242.

We will now suppose that instead of a stripe it is desired to make another pattern. Take, as an example, a chess board pattern, alternate squares of black and white. We have only to combine the two foregoing patterns and we have the thing at once. Fig. 242 is the design for this. The square A of the design is white, B is black, the result being obtained by the lifting marks being changed in the alternate squares from the white thread to the black, and *vice versa*, always carefully observing that when the white is intended to be brought to the face the lifting mark must be on the black pick, and when the black is to come to the face the lifting mark must be on the white pick.

It will be easily found out if it is on the wrong pick or thread by coming into immediate collision with the working dots or crosses, which it will never do otherwise.

We may now produce more elaborate and extensive figures. The readiest and surest way is to sketch the design upon squared design paper, colour it over with some transparent colour, put on the working dots for both cloths all over both the coloured and uncoloured portions, then, instead of having to go over the whole design with the lifting marks, the coloured portion answers for the lifting marks when cutting the cards for, say, the white

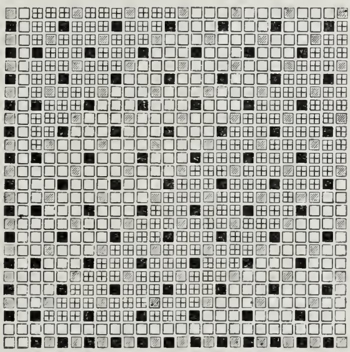


Fig 243.

cloth, and the uncoloured portion for the black cloth, as shown in Fig. 243, where the coloured portion is represented by the small cross inside the square.

The reason I have dealt so fully with the lifting marks as I have named them in the examples just given, is, because I find it much more readily understood and followed up generally by students, than if the colouring was given first; because the colouring being painted over all the threads which form both cloths it is difficult in the extreme to separate in the mind of the student one cloth from the other, and to make him understand that every

alternate pick and every alternate thread represented on the design paper belong to separate cloths.

Fig. 244 is an example of a figure worked in this manner, and Fig. 245 is the same thing worked with the lifting marks, which shows the working clearly, but when the principle is thoroughly understood, the value and

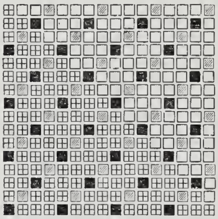


Fig. 244.

simplicity of the method shown at Fig. 244 will be obvious at a glance.

In all these examples I have kept to plain cloths; that is, the two cloths, although they form figures by passing to reverse sides of each other, are in themselves each quite plain; but, of course, it is not at all necessary to keep to plain cloths, they may be twilled or otherwise equally as

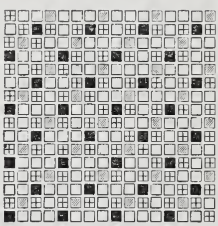


Fig. 245.

well. Fig. 246 is an example of a design upon twill ground. Other grounds may be worked equally as well on the same principle. Nor is it necessary that the two cloths should each be solid in colour. They may be varied in every conceivable form, one solid colour, and the other striped or checked, as fancy may dictate.

The way in which the figure is formed will perhaps be made more intelligible by reference to the section, Fig 247, which shows the manner in which the face cloth passes to the back, and the back cloth to the face, for the purpose of forming the figure.

We must now return to what was said at the beginning of this chapter respecting casting out in harness. Assuming

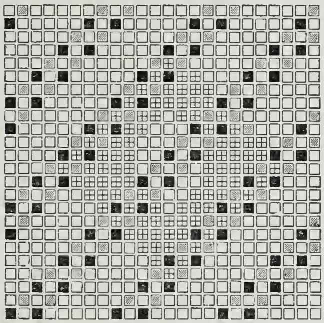


Fig. 246.

that we are working with a Jacquard having 304 hooks, the first three designs given, Nos. 226, 227, and 228, would not require any casting out; as has been already shown they occupy such a number of ends as will divide evenly in 304; but in Fig. 229 that is not the case. In this design the pattern occupies twenty ends, then $304 \div 20 = 15 + 4$,

Fig. 247.

consequently, there being a remainder of four, four hooks must be cast out, or allowed to remain idle, otherwise the pattern could not be made to meet and join properly at the sides. Again, in Fig. 230 the pattern occupies thirty-two ends, then $304 \div 32 = 9 + 16$; consequently, there being a remainder of sixteen, that number of hooks would

require to be cast out, and so in all cases where the design will not divide evenly in the total number of hooks in the machine. After dividing the total number of hooks by the ends in the pattern the remainder must be cast out so as to make the pattern join properly at the sides.

Another reason for casting out in Jacquards is to change the sett, or number of threads per inch, from one number to another. In all cases the harnesses are tied up to what is termed a certain sett or degree of fineness, or with a certain number of threads per inch, and it frequently happens that some other sett is desired to be woven than that which the harness represents. This sett must of necessity be lower than that of the harness, because, although we may reduce the sett by casting out, we cannot add to it. Therefore, in any case where the harness is tied up to a given sett, and it is desired to weave some lower sett in the same harness, it becomes a question of simple proportion. Supposing the Jacquard to contain 304 hooks, and the harness tied up to sixty sett (Bradford or any other system), and it is desired to weave a fifty-four sett cloth, then as 60 : 304 : : 54 : 283, consequently the number to be cast out is represented by the difference between 283 and 304, which would be twenty-one; but it is not usual to deal with odd ends, therefore twenty might be cast out, and so leave a number which would be a convenient dividend for patterns. Or suppose the machine to contain 400 hooks, and tied up with eighty threads per inch, and it is desired to reduce that to seventy per inch, then as 80 : 400 : : 70 : 350, consequently the difference between 350 and 400 represents the number of hooks to cast out or remain idle.

These are the two principle reasons for casting out, and in any case by observing these two rules little difficulty will be experienced in adapting the harness to any design or sett,

PILE OR PLUSH.

All the varieties of cloth hitherto dealt with belong to, or are combinations of, two of the three primaries, which were pointed out in the early part of this work; and, before in any way dealing with the third of these primaries, it will be necessary to examine another, which apparently would belong to a quite different species, but in reality belongs to the two already dealt with, the different effect being produced partly in the process of weaving, and partly by another process after the cloth is woven.

Pile weaving is, like all other kinds, capable of producing great diversity of patterns, not only in itself but in conjunction with figures; magnificent effects being produced by velvet forming figures upon silk grounds of various colours. Patterns of various colours in loop pile, as in Brussels carpet, imitations of skins of animals of almost every description, and in other ways, calling forth the ingenuity of the caterers for the public in the production of textile fabrics, which may deservedly take rank as works of art.

Loop pile is the first and simplest kind of pile made, and consists of a plain ground cloth woven in the ordinary manner, and having upon it a pile formed by a separate warp, which is bound into the ground cloth in the manner shown at Fig. 50, page 166, the loop being formed by wires being inserted under the warp which is to form the loop, in the process of weaving, and afterwards drawn out; the size of the loop being regulated by the thickness of the wire used.

Cut pile is woven in precisely the same manner as the foregoing, the difference being that instead of the wire

being drawn out it is cut out, either by means of a knife run down a groove in the top of the wire, or the end of the wire being furnished with a knife which cuts its way as the wire is drawn out.

There are various ways of altering the quantity of pile upon the surface of a cloth, the manufacturer being guided by the purpose for which it is intended, as well as by the thickness and quality of the material being used. In the first place it may be very easily regulated by the number of threads of pile warp per inch, care of course being taken that the threads may not be so far apart that the pile will appear in rows, showing up the ground cloth between each. Again, the pile, instead of being bound in every pick of the ground cloth, may be bound in every alternate one, or otherwise as may be desired.

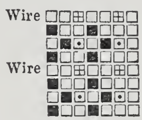


Fig. 248.

Another point to be observed is that the whole of the plush warp need not be brought over the wire at once, but every alternate thread brought over the first wire, then the other half over the next wire, the portion of the pile warp which is not being worked up being worked into the ground, as shown at Fig. 50; thus not only making the ground cloth a much finer and firmer one, but also binding the pile much more firmly into the cloth.

Before going further, it may be desirable now to show how the patterns for velvets or warp pile fabrics, are arranged upon the design paper, and then to examine how figures may be produced by forming velvet upon a plain or other fabric.

To turn first to the common velvet, or where all the pile warp is raised at once for the formation of the pile, the

design Fig. 248 shows the arrangement. In this the ground threads are represented by the solid squares, and the pile threads by the dots and crosses, the one indicating where it binds into the cloth, and the other where it passes over the wire. From this it will be seen that there are two ground threads to one pile thread, and three ground picks to one wire or row of loops. It will be further noticed that when the wire is inserted—as indicated by the word wire,

Fig. 249.

and the crosses—the pile warp issues from and returns to the cloth between two picks, which are exactly alike, as shown in the section Fig. 249, by this means not only holding the pile firmly into the cloth, but forcing it to stand erect.

The arrangement for the working design for utrecht velvet is slightly different, as shown at Fig. 250. The wires are again shown by the crosses, and the pile thread always binds into the fabric along with its neighbouring

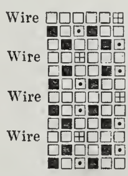


Fig. 250.

ground thread; a section of this is shown at Fig 50, page 166.

Where figures are to be formed of velvet on a plain, or any other ground, the structure of the cloth, and the mode of binding the pile into the ground cloth remain exactly the same; the figure is formed by simply not bringing the pile warp over the wire, where the ground cloth

is to be visible, and lifting it over the wire where the figure is to be formed. The readiest method of making the design for figured velvets, is to paint the pattern on paper after the manner indicated with reference to double cloth, and as the ground picks remain the same throughout, and the figure is formed solely by the warp being brought over the wire, in cutting the cards for the wire cut only for those threads which, as indicated by the colouring of the design, are required to be raised, and allow the rest to continue to form part of the ground cloth only.

For very strong heavy cloths, such, for instance, as Brussels carpets, the pile warp does not pass actually to the back of the cloth, as shown at page 166, but passes between two weft threads, as shown at Fig. 251, where two separately coloured pile threads are shown, each coming up at a different time to produce a figure. So far as the ground warp is concerned those two binding picks both go in the same shed, but one passes above and the other below the pile warp, so holding it firmly between them the weft being shown by the dots, and the ground warp by the thin black line. Upon this principle of working, figures may be produced by using various coloured yarns, or all with one colour, by bringing up the pile at intervals, the pile being either looped or cut.

It will be seen from a comparison of Fig. 251 and Fig. 50 what is the difference between an ordinary velvet and a carpet pile. And it will be also apparent what an advantage the latter possesses for use, because of the structure, and of necessity the increased bulk of the ground, or body, of the cloth.

After what has been said it does not require much ingenuity to arrange designs for Brussels or other similar carpets. The one thing to regard, so far as the arrangement of the design upon paper as a working design, and apart from its artistic merits, &c., being to take care that the

proper thread is brought to the surface at the proper time. The ground working remaining the same throughout.

The length of pile is a very important matter, especially if the object is to imitate the skins of animals. The length of pile must be in accordance with the nature of the skin to be imitated. Take, for instance, the sealskin, which is very largely imitated, sometimes by the warp pile principle, and sometimes by the weft pile principle. The pile or nap of a sealskin is of the medium length, from a quarter-inch to about half-an-inch, somewhat longer than an ordinary velvet, while an imitation dogskin of the long curly or wavy kind has a very long pile or nap, ranging up to an inch in length. In both these kinds of skins there are important features to be observed, quite apart from the weaving. Sealskins are very often made with a sort of

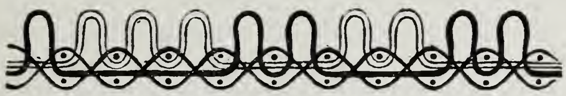


Fig. 251.

tan-coloured ground, and the tips of the pile are coloured a very dark brown, which gradually gradates down towards the ground, thus giving it an exceedingly rich appearance. This tipping, as it is termed, is done after the pile is woven and cut, and is really a part of the finishing process.

In the imitation dogskin the curl or waviness is produced by a preparation of the pile warp before weaving. The yarn is crimped, the length of crimp being regulated by the amount of waviness it is desired to give. The crimping is set in the yarn by a steaming process, the yarn is then made into a warp, and woven over wires and cut. The moment it is cut it falls into the crimps again, and thus produces that wavy shagginess.

No matter what the effect on the face may be, if the pile is a warp pile the principle of making is the same. If

the pile is of a material which is very likely to pull out easily it is more firmly bound into cloth by interweaving, and *vice versa*, but all other effects, such as curliness, waviness, colouring, &c., are produced in the preparation of the yarn before weaving, or in the finishing. Numbers of various effects in imitation skins might be given, all produced by different processes, but the object of this work is to deal with weaving only, and to lay down the principles so that they may be applied to all classes of trade, and not to detail the manner in which any particular cloth is made, otherwise there might be no limit to the work, and a vast amount of information might be contained in it which would be of no value except to those engaged in that special branch of trade.

Weft piles are produced by the material of which the pile or nap consists being thrown in as weft instead of warp. The appearance of a weft pile is usually totally different to that of a warp pile, inasmuch as the warp pile being woven over a wire and cut down, the pile is made all of a length, and unless in the case of a very long pile, or when the yarn has previously undergone a preparation for the purpose of producing some special effect, all warp piles present a smooth even surface, the tips of the pile only being presented to view. But in the weft piles this evenness cannot be well maintained, partly in consequence of the manner in which the pile must be bound into the ground cloth, and partly in consequence of the method of cutting making it almost a matter of impossibility for both sides of the loop to be cut of an equal length. There are one or two exceptions to this which will be mentioned, but they are only in special makes, and have each peculiar characteristics.

As an example of weft piles we will take an imitation lambskin upon a twilled cloth. The design, Fig. 252, shows the manner in which the weft, which is to form the pile,

may be bound into the ground cloth. Two ends are raised at a place, and at such distances apart as to allow for the length of pile required. These bindings, it will be observed, are not in exactly regular order, that is, they do not run in straight lines like velvet. The reason of this is that the material of the pile being of a thick and soft character—being usually of the finest and softest wool, possessing the best felting qualities—it must not be so thickly bound in the ground cloth, consequently it is spread over the surface in the manner shown, so as to equally cover the surface without showing in rows, or leaving any bare patches. This, after the cloth is woven, is cut with a knife, as shown at page 167, the point of

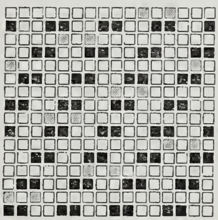


Fig. 252.

the knife being inserted under the weft, which is floating over the cloth, and pushed forward lengthwise of the cloth, the point of the guide always following the course of the pile, and raising it up to the knife which severs it. This process is repeated from one side of the cloth to the other, the cutter usually beginning at the right hand selvage of the cloth. The process of cutting is generally done after the cloth comes out of the loom, the cloth being stretched in a frame for the purpose.

Pile made upon this principle, as before remarked, is not even on the surface, as is the case with warp piles. This will be easily understood from the manner of cutting it, making it almost a matter of impossibility to run the guide under the courses of the pile in such a manner as to

ensure the cutting exactly in the centre of the weft float. This is remedied afterwards by the shearing machine, known as the cross cutting machine, and sometimes by the perpetual cutting machine.

After the pile of a lambskin is cut it presents something of the appearance of a very coarse velvet. To give it then the character of the skin of the animal it is intended to imitate, it is kept moving through a strong soap sud for some hours, until the pile on the face of the cloth becomes felted in patches, thus producing the semi-curly, semi-wavy appearance peculiar to the skin of the lamb.

With regard to " Velveteens " and such fabrics, where the pile is very short, the reader need only be referred to my work on "Design in Textile Fabrics" already mentioned. Where he will find a considerable amount of information of what may be called a special character.

In the imitation of other skins the principle of weaving remains somewhat the same, the length of the pile being regulated to suit the character of skin required to be imitated, and the firmness of the binding into the ground cloth being regulated by the nature of the material used for pile, and the subsequent processes it will have to undergo. To illustrate this we will now take, as an example, a pile made of mohair yarn, where it is desired to have the pile firmly bound in the ground cloth. And here it may be observed, in the use of mohair, which is of a very smooth and slippery character, it is necessary that it should be very firmly bound, otherwise it is very liable to pull out in wearing, and indeed even in the process of cutting. Fig. 253 is a design for this kind of pile. On examination of this design it will be found there are four picks of pile weft, which are represented by shaded squares, and one pick of ground weft, represented by black squares. These four pile picks are so arranged as to form one continuous pick,

passing over and under alternate threads, thus constituting one ground pick of plain cloth. The ground pick is also plain, taking the contrary thread of warp up to the pile pick, so forming a perfectly plain ground, with the mohair pile standing up out of it. Care should be taken that the succeeding series of pile picks do not leave the cloth at the same point, but are distributed over the surface in the same manner as the preceding example. Although but one ground pick is shown, or mentioned here it is better to insert two ground picks between the pile picks, so as to give firmness to the structure. One of the two would necessarily go into the same shed as the pile, but that would be no disadvantage, it would give more firmness to it. In the

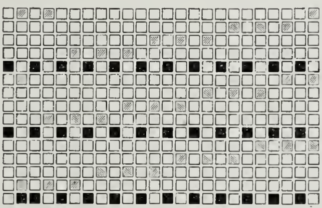


Fig. 253.

design here given the arrangement is not the best which could be devised, the order of changing being on the principle of a three-end twill. Had space permitted it would have been much better arranged on a satin principle, which would be the best plan to adopt in practice. Another advantage of this kind of pile weaving is that in addition to the firmness with which the pile is bound into the ground cloth—becoming, as it in fact does, a part of it—the manner in which the pile threads are nipped together at the point where they issue from the cloth, ensures them standing quite erect; indeed a good mohair pile made in this manner, with steam blown through it for several hours after being cut, will stand almost any amount of pressure, and yet spring back to its original erect posi-

tion, without being in any way deteriorated. In this kind of binding the length and quality of pile must be determined by the number of pile picks which go to form one complete pick, and the proportion of complete picks to ground picks. The greater the proportion of complete pile picks to ground picks, the fuller the pile will be, and the less the proportion of pile picks the thinner the pile. In this manner scope is given for the production of cloths of any quality, and at almost any price.

These are the distinct principles upon which pile cloths are made, of course being capable, like everything else, of a vast, indeed an almost endless variety of changes; for instance, a short silk or mohair pile may be made with a

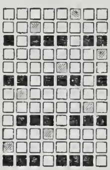


Fig. 254.

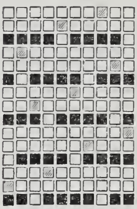


Fig. 255.

long pile scattered thinly over it, of some other material, or of a different colour of the same material, as in the case of the chinchilla; or a short woollen pile ground, with thick worsted or mohair issuing at intervals from it. Or, we may take the case of piles of a shorter and more general character, such as the one represented by the design, Fig. 254, in which there are two plush picks to each ground pick, the plush being bound by one end only, and arranged after the order of an eight-thread satin, and the ground picks being worked as a four-thread satin. Or, take the design, Fig. 255, in which the plush is arranged as a ten-thread satin, and the ground as a five-thread satin. Both of these are of the velveteen type, and fairly represent the principle upon which such cloths are made. In all

plush arrangements of this description the binding of the plush picks should be arranged in a regular order, so as to make regular courses for the knife to cut it. The length and quantity of plush may be varied at will, and the working of the ground may be regulated to suit any pattern, or in accordance with the quantity of material desired to be put in it.

Another method of making pile fabrics is to weave two pieces face to face, the pile warp passing from one cloth to the other, as shown in Fig. 256, and the two cloths being afterwards severed with a knife or by other means. One great difficulty to contend with in this method is to keep

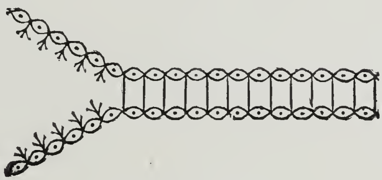


Fig. 256.

the pile of the two fabrics of an even length. To do this the pile warp must be let in very regularly, and the cutting knife or knives must be very carefully adjusted. Numerous inventions have been made by different parties to effect these two objects, with varying degrees of success.

DENSITY OF PILE.

In making pile fabrics it is often necessary to alter the length or density of the pile to meet some demand of fashion, or to suit the cloth to some specific purpose. A mere alteration in length is easily met. In weft pile it simply means an alteration in the number of ends over which the weft is allowed to float; and in warp pile the alteration is made by altering the size of the wire used. But it must necessarily follow that when the length of weft pile is altered, the density must also be altered at the same time,

unless some provision is made to meet it. For example, if the weft has been floating over the warp for half-an-inch, and then it is altered to an inch, and no corresponding alteration is made in the number of picks per inch, then the density of the pile is of necessity reduced by one half, that is, there are only half the number of pile threads issuing from the cloth in a given space, consequently to counteract this there should be double the number of picks of pile weft per inch to obtain the same degree of density as exists in the first cloth.

At all times when such a question may arise, it may be treated simply as one of proportion, and the number of warp threads over which the pile floats taken as the unit of measurement.

Suppose for instance, that a pile is made floating over 16 threads of warp, and it must be increased in length to 26 threads; the first cloth has say 60 picks per inch of ground weft, how many should the second have? then as $16 : 26 :: 60 : 97\frac{1}{2}$, so that it would require $97\frac{1}{2}$ picks per inch of ground weft in the second cloth to give density equal to the first cloth. But in all probability this would be an unsatisfactory mode of obtaining the required degree of density, because either it would be difficult to introduce $97\frac{1}{2}$ picks when 60 had been used, or the cloth would be much heavier, and probably unsuited for its purpose. Then in such a case, the best plan is, in most cases, to introduce more plush picks between each ground pick, as for example, if the first cloth had two plush picks to one ground pick, the second would require three, and the slight difference in density could then be made up by a slight increase of ground picks per inch.

An alteration in the fineness of the ground cloth will have an effect in altering the density of the pile. If more warp threads per inch be introduced, and the pile weft allowed to float over the same number, then the length of

the pile is shortened, and the density increased in the same ratio, and of course any alteration of the cloth must have an effect upon the pile.

At all times this alteration can be determined by simple proportion, and a corresponding alteration made in the opposite direction to counteract it when desired, but it must always be borne in mind, or the results would be sometimes rather serious.

The alteration of density of warp pile is made either by introducing more wires, and consequently more picks per inch, by more warp and pile threads per inch, or by thicker yarn. It will not be a difficult matter, whichever method be adopted, to determine the exact amount of increase or decrease, because it will be in direct ratio to the alteration in either the quantity or thickness of the material employed.

GAUZE WEAVING.

Having in the foregoing chapters dealt with the two primaries, plain and figure weaving, their various combinations and applicability to the production of various kinds of cloth, which, although having on the face of them little to indicate that they belong to either one or the other of these two families, yet on a close examination of their constitution and character undoubtedly proclaim themselves the immediate descendants of them, and conclusively prove that no matter what name they assume, or under what guise they appear, they retain all the family characteristics, and indeed prove that only two principles can be involved, we now come to the consideration of the third of the primaries, viz., gauze weaving, which in its principle is totally different from the two preceding ones. The two primaries, plain and figure, may be said to comprehend all varieties of cloth in which the threads of the warp lie parallel to each other, and are crossed at right

angles by the weft, while gauze may be said to consist of all varieties whose warp threads do not lie parallel to each other in the cloth, but are either twisted together, as shown

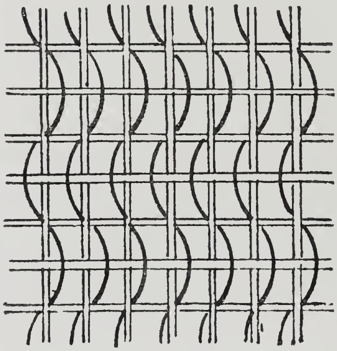


Fig. 257.

at page 168, or otherwise crossed in the cloth in the process of weaving.

The first step in the direction of combining gauze with other orders of weaving, is a species of cloth known

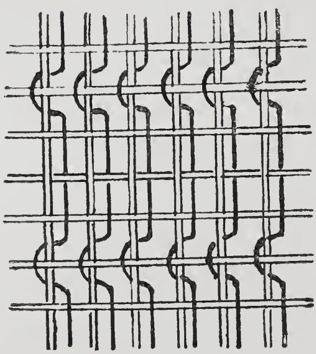


Fig. 258.

by the name of leno, and which is in fact a combination of gauze and plain cloth, but which has a decidedly gauze effect, as shown at Fig. 257. A close examination of this

plan will show that it is really a combination of gauze and plain cloth, the picks G if separated from the others would form a perfectly plain gauze with the warp, as shown at Fig. 53, page 168.

Fig. 258 shows another combination of gauze and plain cloth, and is sometimes known as leno. In this it will be found that the warp threads are given a half turn round each other at every fourth pick, the intervening picks being perfectly plain, thus making it an intermediate between a plain cloth and a plain gauze. Perhaps a brief description

Fig. 259.

of the process of leno and gauze weaving will simplify and assist to a clear understanding of the principle.

For leno and gauze weaving, there is, in addition to a pair of plain healds, another of a different construction, which is known by the name of doup. This doup is a plain heald, with the addition of a loose half heald, which is shown at Fig. 259, and which passes through the eye of the lower half, and through the upper half. The warp threads are drawn through the two plain healds in the ordinary manner. The

doup heald is then placed in front of them, and every alternate thread is drawn through the loose half-heald of the doup crossing under the intermediate thread, as shown in Fig. 260, where D is the doup, and 1 2 the plain healds. In the process of weaving, when it is desired that the open or plain pick shall be put in, the loose half of the doup heald is allowed to rise along with the plain heald through which the crossing thread is drawn, the intermediate pick being also plain by the simple process of raising the second plain heald; then for the purpose of crossing the threads all the doup heald is raised, and the plain heald through which the crossing thread is drawn is depressed along with the other plain heald, in this manner causing the crossing

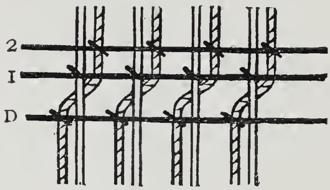


Fig. 260.

thread to take a half-turn round the other thread, as shown in Fig. 258.

It will be apparent that in this process one-half the warp at the moment of crossing must be drawn considerably tighter than the other half, and unless some provision is made to avoid this, the consequences to the warp must be somewhat disastrous. This may be provided for in two ways. The first and oldest-fashioned method is to have the warp on two beams, the beam carrying the crossing portion being furnished with spring weights, so as to give off warp when crossing and then spring back as the doup heald settles down. The second, and now generally adopted method, is by means of what is termed the slackener. This consists of a species of lever. The warp

is all wound upon one beam, the crossing warp is separated from the other and passed over the slackener, and then through a pair of lease rods placed between the slackener and healds, as in ordinary plain weaving. During the plain weaving the slackener remains stationary, but when the warp is crossed a cord attached to the arm of the slackener is connected so as to operate with the doup heald, and allow the warp to go in just sufficient to prevent it chafing the straight thread, and is then drawn back into its former position by means of a strong spring. This latter method would not apply in all cases, but only where very little crossing takes place, or where the take-up of the crossing warp is so slight that it does not become tighter than the rest of the warp, otherwise, not only would considerable breakage take place in the warp, but it would be a very difficult matter indeed to weave at all, and the appearance of the piece would be anything but satisfactory. Therefore in many cases it is absolutely necessary that the first method of having the crossing warp upon a separate beam or roller should be adhered to; the latter only being resorted to when circumstances will permit.

The order of raising the healds to weave the two patterns given would be as follows:—

For Fig. 257. No. 1 heald
,, 2 ,,
Doup ,,
No. 2 ,,

and so on. For Fig. 258 it would be
No. 1 heald
,, 2 ,,
,, 1 ,,
Doup ,,

To return to a plain gauze, pure and simple, that is, with the warp threads crossing between every pick. The same healds and doup are employed as in the former case,

but instead of the plain pick as in lenos, the warp threads cross each other every pick, as in Fig. 53, page 168, the method of crossing being in no way different from the

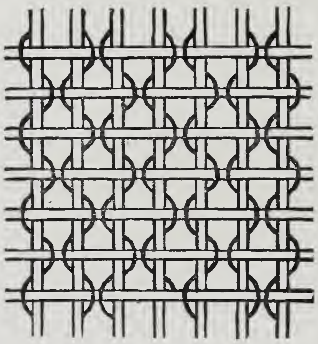


Fig. 261.

leno crossing. The crossing may of course be in either direction, from left to right, or right to left, in the douping.

Some very excellent effects are produced in gauze by reversing the gauze twist, that is, by making every alternate

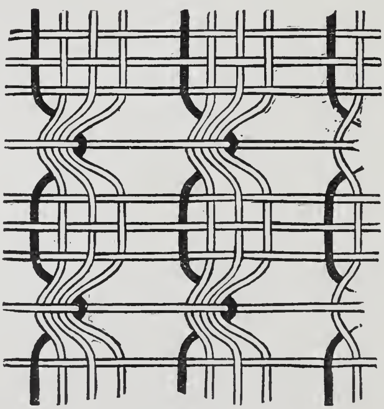


Fig. 262.

pair of threads twist round each other in opposite directions, as shown in Fig. 261. This effect is considerably heightened when the two threads are of different colours,

or a variety of patterns may be produced by arranging the reversing and the colouring in stripes, and if desired, checking them to match. Patterns of a different character are also made by having a certain number of splits in the reed full of warp, and an interval of space in which there is no warp, the crossing of the warp threads preventing

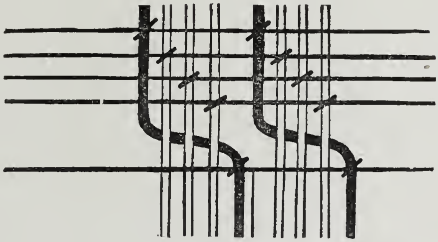


Fig. 263.

them slipping out of their place and producing a frayed appearance, as would be the case if an interval of space were left in a plain cloth; or the crossing thread may be made to cross over more than one thread, and patterns formed by combinations of plain and gauze as shown at Fig. 262, the draught and douping of which is shown at Fig. 263.

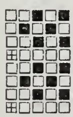


Fig. 264.

The order of raising the healds is shown at Fig. 264. Where the lifting of the doup is indicated by a ⊞

Again, this may be varied and a pattern of a check character produced by weaving a distance corresponding with the stripe in the warp quite plain, and a distance corresponding with the interval of space with gauze crossing,

or other effects produced by combination of plain gauze and plain cloth, as in Fig. 265.

The order of raising the healds can be readily found by following the individual warp threads, and bearing in mind

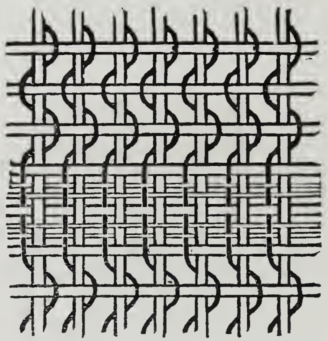


Fig. 265.

through which healds they are drawn, and when the crossing takes place taking care to raise the doup.

One rule must be carefully observed when a pure gauze crossing is required, always to raise the heald carrying the crossing thread *immediately before and after the doup.*

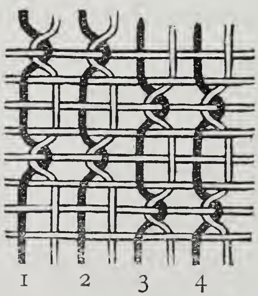


Fig. 266.

The reader having followed carefully the foregoing description of gauze weaving, and having made himself master of the various methods of arranging patterns for healds given in previous chapters, will have little difficulty

in making himself master also of pattern weaving in gauzes. Patterns in gauzes may be arranged on three principles,—the first, by making patterns *in* the gauze by introducing plain or other working, or varying the order of crossing of the several sets of threads; the second by arranging gauze and plain, or gauze and figure, in stripes, &c.; and the third by making patterns *on* the gauze with

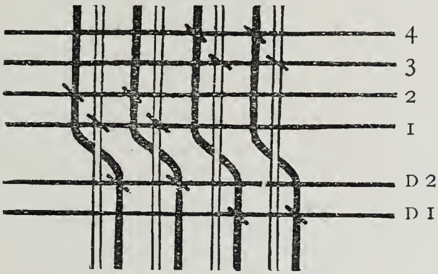


Fig. 267.

what may be termed figuring threads; this last is termed lappet figuring. Then as to the first kind, it has been shown on page 270 how the crossing thread is drawn through the doup and across the plain thread. In plain gauze only one doup is used, but it must be evident that if a pattern is made with the gauze, more than one doup must be used. Fig. 266 is an example of a small pattern made with two

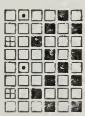


Fig. 268.

doups, the manner of drawing being shown at Fig. 267, and the order of raising the healds at Fig. 268. When the first doup is represented by a ⊞ and the second by a ⊡.

Although this pattern is given as being woven with two doups, yet it may very well be woven with one. Suppose the ends are douped as shown in Fig. 260, then by lifting the healds as in Fig. 269, the same pattern will be produced.

There is this one objection to it, that the doup is lifting at every alternate pick, and consequently there will be more wear and tear, but as will be shown presently, this mode of working may be well adopted for weaving figured patterns. The same rule may be observed here as in arranging patterns for ordinary healds, viz., that all threads which

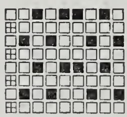


Fig. 269.

work the same may be drawn upon the same doup. In this pattern, the threads 1, 2, would be repeated at the fifth and sixth pairs, and all working alike, may be drawn upon doup 2; threads 3 and 4, working alike, may be drawn upon doup 1, the crossing or plain weaving being effected as desired, in the same manner as explained in the leno weaving, due

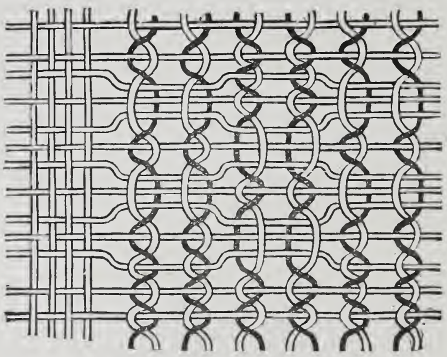


Fig. 270.

regard being paid to the pattern, which of course may be varied as far as the extent of the drafting will permit. Fig. 270 is another example upon a rather more extensive scale, the same rule being observed as in the last pattern. In this case at intervals in the pattern several picks are introduced into one shed, giving a totally different effect to

the pattern. The draught is shown at Fig. 271. In this pattern it will be observed that a few plain ends have been introduced up the side to form a stripe. In the same manner plain picks might be worked in so as to form a check effect.

With care in the arrangement of the doups a very great variety of patterns may be produced; more especially when more than one doup is employed; and even with one doup with skilful use very pretty effects may be made. Of course many of the more elaborate gauze patterns have been superseded by lace, or have gone out of existence for some other reason. Fig. 272 is a curious sample of gauze

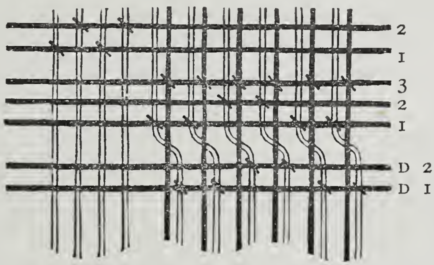


Fig. 271.

weaving. This has been reproduced by photography from a small piece of fabric which is in my possession, and engraved direct from the negative. The pattern as shown here represents only a small portion of the fabric, but is sufficient to disclose the different kinds of crossing employed. In the larger sample the large meshes—if they may be so termed—are made to form a pattern after the manner of lace. I have thought it worth while to reproduce this for the purpose of showing those who may not have had an opportunity of seeing some of the curious productions of the loom, what could be done by what is now looked upon as the primitive hand loom. This pattern must have been made in the early part of the present century.

Coming now to the use of the Jacquard we have an unlimited power for the production of patterns; whether an ordinary harness with one or more doups in front be employed, or a harness specially prepared for gauze weaving be employed. In the former case it is probable that very few really know what they can do with an ordinary harness for gauze weaving, and it would not be easy to

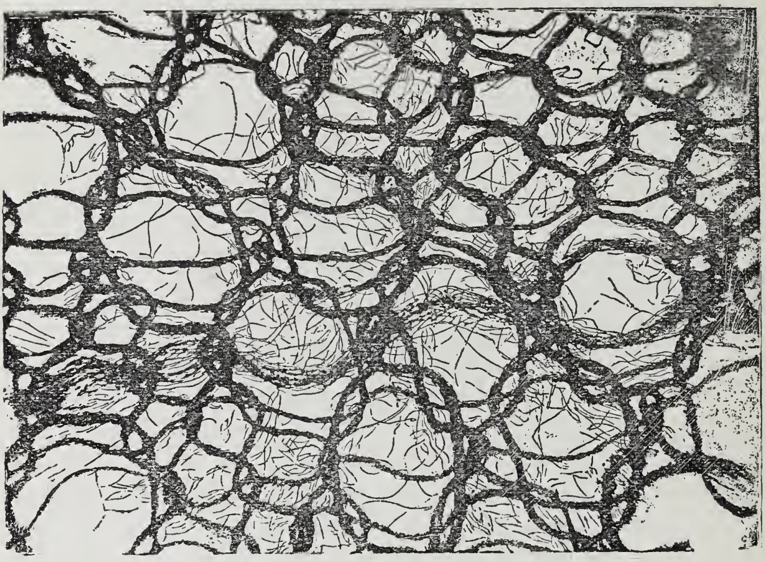


Fig. 272.

convey a knowledge by mere writing of what can be done, however the general principles may be conveyed, and the simplest mode of arranging designs for them explained.

Suppose we begin first of all by treating the matter as though we were employing a number of healds, for the harness is nothing more than a large number of healds arranged to occupy little space, and actuated by a particular mechanical arrangement. Take the draught and douping

plan shown at Fig. 273, there eight healds are represented and one doup. Now this would be a fair representation of each row of harness cords, so that a whole harness would be merely a repetition of those eight healds. In this small space even there is considerable room for making a large variety of patterns. To begin with, suppose it is required to make

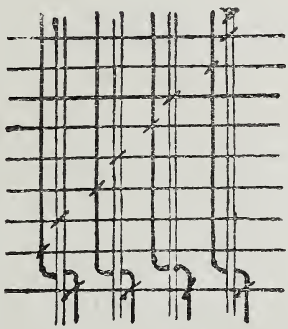


Fig. 273.

a diagonal pattern of plain cloth and plain gauze alternately, then we have only to proceed after the manner shown at Fig. 269 of producing the pattern Fig. 266. The plan shown at Fig. 274 explains how the doup and healds would have to be raised to produce such a pattern. Here it will be noticed that the doup is raised at every alternate pick, and that

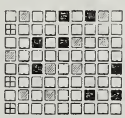


Fig. 274.

when it is raised none of the other healds are raised; then on the intermediate pick of weft, those healds which carry the crossing threads, viz., 1, 3, 5 or 7 are raised for the purpose of forming gauze, and when plain cloth is wanted the intermediate threads, or those carried by the healds No. 2, 4, 6, or 8, are raised. Again the great bulk of the cloth may be plain, and only here and there a perforation

made by the crossing taking place. Take for example Fig. 275, there as indicated by the shaded squares, only an occasional crossing takes place.

To follow this further, designs may now be made for the

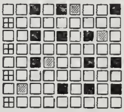


Fig. 275.

jacquard, and which will show how far figuring may be carried, when only one doup is employed.

Suppose the pattern given at Fig. 276 is desired to be made in gauze and plain cloth combined, say the black portion to be gauze, and the white portion plain, then the

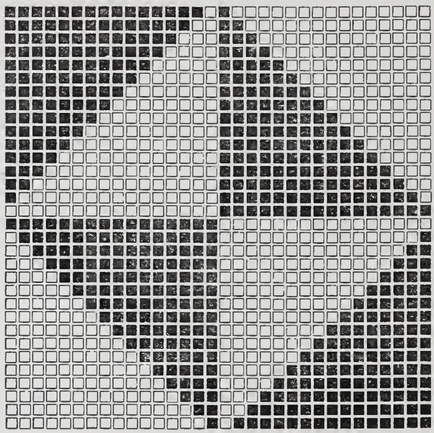


Fig. 276.

working design is given at Fig. 277. An examination of this will show that the arrangement is in strict conformity with that shown in Figs. 274 and 275. In making large designs it would be a tedious process to have to dot them all over as shown here, but that can be easily avoided by laying the design on paper in a wash of colour, and giving

instructions to the card cutter how to proceed. The procedure is, of course, uniform throughout. Wherever gauze is wanted, the heald or harness cord carrying the crossing thread is lifted, and in such a case as this it will always be the odd or always the even end of each row; and where plain cloth is wanted it will be exactly the reverse.

One thing must be made clear here, viz., that by this mode of working with the harness, when plain cloth is combined with gauze, only one pick can be inserted in

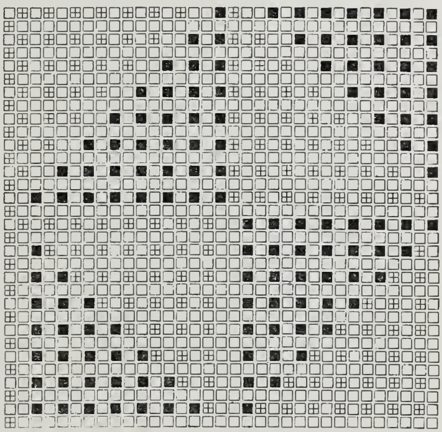


Fig. 277.

one shed of the gauze, simply because the plain cloth having to be formed by the doup and second heald, or that which carries the thread crossed by the doup thread, the doup must of necessity be raised at every alternate pick. Although only one pick can be inserted in each shed, yet it does not follow that the crossing thread can only be made to cross one warp thread; it may be made to cross any number, and the arrangement of the design will be practically the same, the difference being simply that the designer must remember that instead of every

alternate thread being a crossing thread, that it is every third, or fourth, as the case may be.

Attention may now be turned to figures of a rather more complex character. These given are simply a combination of plain gauze and plain cloth texture, but it may be desirable to form a figure with warp or weft, and surround it with gauze. Before going further one word of warning may be given to the beginner, that is, that it is never desirable to form a warp or weft figure upon gauze without separating it from the gauze by a few threads of plain cloth, because if not so separated the crossing of the threads in the gauze will have a tendency to draw each

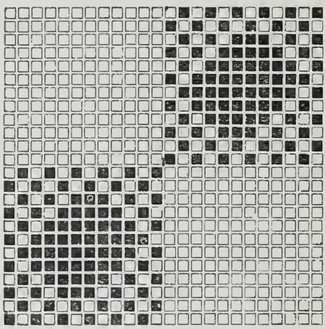


Fig. 278.

other out of their straight course, and so cause the figure to be distorted.

Suppose it is desired to form a figure of the character given at Fig. 278. Where a warp figure is made upon plain ground and the open square to be gauze. This may be produced by the working design given at Fig. 279. In this it will be seen that the plain cloth and gauze is produced in the manner already described, and the warp figure is produced by lifting such threads as are necessary for the formation of the figure, as shown by the dots ⊡. It will be necessary to explain here one matter, which might

otherwise appear incomplete. It is well understood that when a warp figure is to be produced, the whole of the warp threads are raised, except perhaps some which may be left down for binding purposes ; but in this case, on the pick when the doup is raised, the marking on the design paper appear to represent only every alternate thread as being raised. It has only to be borne in mind that the intermediate threads are raised by the doup, and the raising of the whole of the warp is provided for where the dots are placed.

It will generally be found that the best effects are produced in this class of gauze weaving, by keeping to

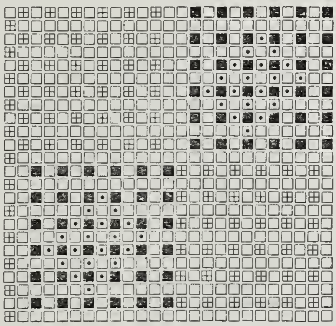


Fig. 279.

figures of a geometrical character ; floral designs may be employed, but as a rule they are not so effective as geometrical arrangements, and again, as the crossing must take place at every pick, the cloths must of necessity be light, and as a consequence, if cloths of some substance are required, it is better to have a gauze figure upon a plain ground than a plain figure upon a gauze ground, that is, the plain cloth should predominate rather than the gauze. For gauze fabrics when it is desired to have more than one pick in each shed in the gauze, and at the same time to produce elaborate figures, harnesses with doups arranged within the harness

must be provided, that is, instead of the common form of doup being employed, a loose slip, or some other form of doup must pass through the eye of one of the harness threads, and so constitute each thread through which such loose slip passes a doup in itself, by this means each individual doup can be actuated at will, and consequently the figure may be made to assume any form desired.

The great majority of figured gauzes are arranged for two threads to cross two as shown at Fig. 280, and usually with three or more picks in each shed in the gauze. By this means, a greater degree of openness in the gauze is obtained, and at the same time a close compactness in the plain cloth

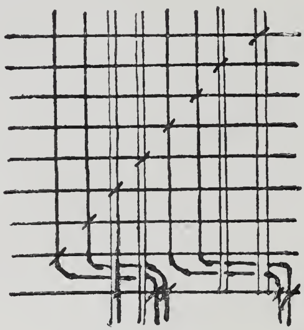


Fig. 280.

and figure, which by their contrast gives greater effect to the fabric.

The principle of arranging the designs for gauzes, whether in healds or Jacquard harnesses, is precisely the same as for any ordinary fabric, only the doup must be borne in mind and raised at the proper time, and of course the working of the doup end will also affect the working of the end which accompanies it.

Patterns may again be varied so as to approach very nearly in some respects to the effect given by figuring threads, by drawing the crossing threads in the doup so as

to cross more than one thread, as shown in the pattern, Fig. 234. Of course in this case the crossing thread does not cross more threads than are drawn into one split of the reed; but this is a rule which is not always observed, otherwise this description of pattern would of a necessity be very limited, but the doups are sometimes placed in front of the reed, the lay being constructed so as to allow of their being placed between the reed and the shuttle race, and a series of needles or wires, which form a sort of false reed, being arranged for the shuttle to run against in such a manner as to leave the threads perfectly free to cross each other the moment the shuttle has passed through the shed, these needles rising and sinking at each pick.

This mode of working is not much in use now, but was necessary in such patterns as that shown at Fig. 272.

Fancy gauzes made upon the second principle, named in page 275, *viz.*, by arranging gauze and plain, or gauze and figured stripes, produce splendid effects in some classes of goods. The principle upon which they are worked is very simple, being only a modification of the plain gauze. Fig. 265 shows a pattern of gauze and plain stripes. The gauze stripe may be worked just as a plain gauze in the ordinary manner, or in a variety of patterns, and the plain stripe being worked only upon the two plain healds; or this may be varied by twilling; or if a Jacquard be used the plain stripe may be converted into a figured one, and so produce an immense variety of effects.

Lappet figures are usually made upon a gauze ground, and consequently belong to the gauze class. Upon this system patterns are made by a number of what I have termed figuring threads. The manner in which the figures are formed is by the threads being passed through a series of needles set in a frame, which is placed between the reed and the shuttle race in a similar manner to the doups

for weaving the pattern mentioned on the last page. This frame is made to slide backwards and forwards from right to left, the needles being raised at the proper moment so as to allow the weft to pass under the figuring thread, and so

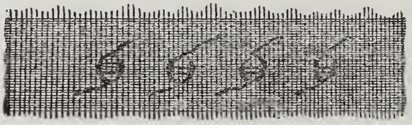


Fig. 281.

bind them into the cloth. For the purpose of producing this oscillating movement of the frame, a wheel is placed at the side of the loom, having grooves cut in it so as to carry

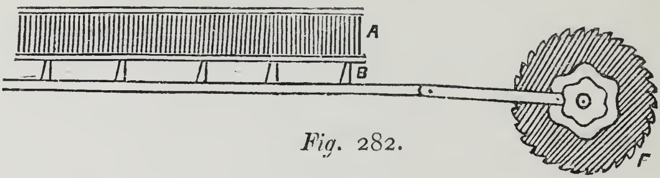


Fig. 282.

the frame the proper distance for the production of the desired pattern. Almost any pattern is capable of being produced in this manner, Fig. 281 being an example of

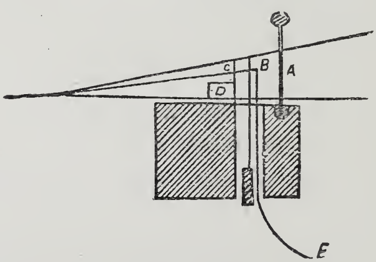


Fig. 283.

a pattern made on this principle, the arrangement of the apparatus being shown at Figs. 282 and 283, one being a front elevation, and the other a section. A is the reed, B the needles which carry the thread, C the needles which the shuttle D runs against, and E the figuring thread, the

motion being given to the figuring needles by the wheel F, which must be cut to the pattern. As the weaving goes on, this wheel moves one tooth for every pick, and by the cutting of the wheel moves the needles from side to side as desired for the production of the pattern.

In many respects this method of figuring resembles what is known as figuring with swivels, but there is not the same scope for the production of elaborate effects which there is in swivel weaving. In the latter system the figures are produced by a series of small shuttles, placed at intervals across the piece, and carrying the figuring material in the form of weft instead of warp, as is the case in lappet weaving. These shuttles form the figure only, taking no part whatever in the formation of the ground cloth, an ordinary shuttle forming the ground cloth, just as in plain weaving, the figuring shuttles being fixed at regular intervals across the loom or frame. Whenever a figure is to be formed, warp is raised at the proper places and the figuring shuttles are passed under it; this operation being repeated alternately with ground picks until the figure is formed. It will be evident that by this arrangement a number of shuttles may be made to take part in the formation of the same figure, and so enable the weaver to introduce a number of colours which, on the lappet principle, would be very intricate and troublesome. The swivel method of figuring is used largely for producing patterns not only upon gauzes, but upon every kind of fabric.

GENERAL ARRANGEMENT OF PATTERNS.

Having in the preceding chapters gone through the three leading principles, and shown the nature of each, and their combinations for the production of an endless variety of patterns, it may not be amiss now to examine into one or two particular makes of cloth, and a general system of arranging patterns for various fabrics. Hitherto I have avoided as far as practicable making special reference to any particular cloth or pattern, except for the purpose of illustrating the general principle upon which all fancy weaving is founded, but there are some cloths which may require some little explanation as to their constitution, and other matters to which it is necessary to devote attention, quite apart from the general principles. First and foremost of these come velvets and plushes, or pile cloths of every description. This class of fabric, although appearing to differ in every essential point from all other fabrics, belongs to, or is at any rate composed of, the first two of the three primaries, laid down in this work; the difference, as pointed out in the chapter devoted to pile fabrics, arising entirely from various processes in the preparation of the yarn, from the processes of finishing subsequent to the weaving, or from additional operations in the process of weaving, such as the insertion and withdrawal from the pile warp of wires so arranged as to leave the pile standing in loops, or with the loops severed so as to leave a surface of the fabric presenting to the eye the ends of fibres, instead of as in other cloths presenting the fibres or the threads composed of fibres laid parallel in the warp, and crossed at right angles or otherwise in the weft.

Another cloth which may be mentioned is one known as the honeycomb cloth, which presents to the eye a series of ridges and cavities, resembling in appearance the production of that wonderful and industrious little insect, the bee. This cloth, although it presents this peculiar appearance, is nothing more or less than a figure of the simplest character, and running in a diamond form on the design paper. Fig. 284 is a design for a honeycomb cloth. It will be observed that at the corner of the diamond a certain number of threads work quite plain, and plain threads run from there in a diagonal form to the corner of the adjoining diamond, the sides of which they really form part; these plain threads really form the centre of a square and become the bottom of a cavity. From these plain

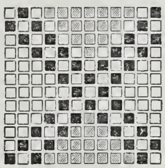


Fig. 284.

threads, and at right angles to each other, the warp and weft begin to form figures by floating over a certain number of threads, beginning with one, the next thread floats over three, the next five, the next seven, and the next nine. Now, herein lies the secret of the formation of these ridges and cavities. This gradual increase in the number of threads which the warp and weft respectively float over, causes them to rise on the top of each other, and so form a ridge, while at the point where they work plain, although it is only for a few threads, the firmness with which they are bound keeps them together, and so forms the bottom of the cavity, by causing the others to rise from them as a foundation, the soft material of which honeycomb cloths are usually made tending in a great measure to facilitate this.

There are other kinds of cloth also which appear to belong to distinct classes, but which on analysis will be found to be composed of one or more of the three primaries.

Another instance may also be mentioned of a cloth which on the face of it bears no indication of the manner in which it is made, but presents an appearance which would be much more likely to mislead one as to the real nature and construction of the cloth. This is ribbed printed tapestry. This tapestry at a glance looks as if it were woven with an ordinary cotton warp, composed of thick and small threads alternately, the worsted passing over the thick and under the small threads, and a cotton pick passing *vice versa*, and so making an apparently thick worsted rib, running lengthwise of the piece, and with a pattern printed upon it. Yet the observer is somewhat puzzled to understand how the printer has managed to penetrate into the crevices between the ribs, which, to say the least of it, would be no very easy task, when the immense variety and delicacy of shades which are introduced into many of the designs are taken into account. But this appearance of the cloth is entirely deceptive, as will be soon found out if the cloth be examined, and a small portion unravelled. So far from the worsted being thrown in as weft it is really as a warp that it is introduced into the fabric, in spite of the appearance of crossing the piece transversely. The warp consists of thick cotton cords, and accompanying each cotton cord in the warp there is a worsted thread already printed to the desired pattern, but in a very elongated form, so as to allow of the necessary take-up in weaving, which, owing to the peculiar construction of this cloth, is very great. The weft consists of nothing but fine cotton, and is woven straight forward, all of one colour; the worsted thread is made to cross over the cotton thread from one side to the other, after the

manner of a gauze cloth, as explained on page 168. A pick of the fine cotton is thrown in, and the worsted thread again passes over the cotton cord, another pick is thrown in, securing the worsted down again, in this way completely covering the cotton on the face of the fabric, and presenting on the back almost the appearance of a plain cloth.

Then this ribbed appearance is simply produced by the distance at which the thick cotton warp threads are placed apart, and the fineness of the cotton weft being so adapted to each other, and to the thickness of the worsted, as to cause the threads of the latter at each crossing to lie close together in such a compact form that they actually appear to be crossing the piece parallel to each other, while in reality each separate thread is laid parallel to itself over the cotton warp at each crossing of the weft.

There are numerous other fabrics to which attention might be called, but the object is not so much to call attention to special fabrics as to deal with the general principles.

Then, that being the case, it will be necessary in the first place to examine the principles upon which designs may be made, and what ought to guide us in the arrangement of a design for any fabric.

Designing for textile fabrics is unfortunately too frequently understood to be the merely mechanical work of arranging the patterns copied from some other material for pratical use in the particular fabric desired; hence the majority of designers are mere copyists. But even taking the designer in this sense, his is perhaps the most important and delicate department in the whole establishment of a fancy manufacturer, for upon his judicious selection and arrangement, and extensive variety of patterns, combined with economy in the disposal and combination of colours, requiring a strict and careful watch being kept on

the changes of fashion and taste, as well as paying attention to the economical arrangement of his styles, so as to cause no unnecessary expense in changing in the looms, and the arrangement and production of cloths, not only novel and beautiful in style, but also giving the best value for the cost, the success of the manufacturer will ultimately depend in a great measure.

Then the qualifications of a designer are not of a superficial nature, taste, of course, being the first requisite. A facility for sketching or delineating any object that may present or suggest itself to him, whether natural, artificial, or imaginary, he should also be possessed of. He should have, too, strong and lively imaginative powers, combined with a thorough knowledge of weaving, particularly of the class of goods with which he is more immediately engaged. But a knowledge of the principles of weaving all classes of goods is extremely valuable, because very frequently ideas belonging to quite a separate branch of manufacture may with advantage be imported into his for the production of new effects.

Taste, then, is the first essential quality of a good designer, as well as of artists or others whose duty it is to produce works which may not only be pleasing to the eye as an adornment, but also may be serviceable in matters of every-day life. A very great diversity of opinion may exist as to what is good taste, every man measuring the taste of others by his own standard, yet there are principles upon which all might be agreed, at least to a considerable extent. "Taste," says Dr. Blair, "is the power of receiving pleasure from the beauties of nature and art. Nothing that belongs to human nature is more general than the relish of beauty of one kind or other, of what is orderly, proportionate, grand, harmonious, new, or sprightly. But although none be wholly devoid of this faculty, yet the degrees in which it is possessed are widely

different. In some men only the feeble glimmerings of taste appear; the beauties which they relish are of the coarsest kind, and of those they have but a weak and confused impression, while in others taste rises to an acute discernment, and a lively enjoyment of the most refined beauties. In general we may observe that in the powers and pleasures of taste there is more remarkable inequality among men than is usually found in point of common sense, reason, and judgment." There are indeed some men who may be supposed to be possessed of a fair share of the latter qualities, but whose taste is remarkable only for one thing, a complete subservience to the expressed opinions of others, praising or condemning in accordance with the expressed or supposed preference of the individual present, and quite prepared to praise where he has before condemned, and condemn where he has before praised, should he consider that the circumstances of the case will permit it, without inquiring whether it can be justified or not.

"The characters of taste when brought to its most improved state, are all reducible to two, delicacy and correctness.

"Delicacy of taste respects principally the perfection of the natural sensibility on which taste is founded. It implies those finer organs or powers which enable us to discover beauties that lie hid from a vulgar eye. One may have a strong sensibility, and yet be deficient in delicate taste. He may be deeply impressed by such beauties as he perceives, but he perceives only what is in some degree coarse, what is bold and palpable, whilst chaster and simpler ornaments escape his notice.

"In this state taste generally exists among rude and unrefined nations. But a person of delicate taste both feels strongly and accurately. He sees distinctions and differences where others see none. The most latent beauty

does not escape him, and he is sensible of the smallest blemish. Delicacy of taste is judged of by the same marks that we use in judging of the delicacy of an external sense. As the goodness of the palate is not tried by strong flavours, but by the mixture of the ingredients, where, notwithstanding the confusion, we remain sensible of each; in like manner delicacy of taste appears by a quick, lively sensibility to its finest, most compounded, or most latent object.

"Correctness of taste respects chiefly the improvement which that faculty receives through its connection with the understanding. A man of correct taste is one who is never imposed upon by counterfeit beauties; who carries always in his mind the standard of good sense, which he employs in judging of everything. He estimates with propriety the comparative merit of the several beauties which he meets with in any work of genius; refers them to their proper classes; assigns the principles, so far as they can be traced, whence their power of pleasing flows; and is pleased himself precisely in that degree to which he ought, and no more.

"It is true that these two qualities of taste, delicacy and correctness, mutually imply each other. No taste can be exquisitely delicate without being correct, nor can be thoroughly correct without being delicate. But still a predominancy of one or other quality in the mixture is often visible. The power of delicacy is chiefly seen in discerning the true merits of a work; the power of correctness in rejecting false pretensions to merit. Delicacy leans more to feeling; correctness more to reason and judgment. The former is the gift of nature; the latter more the product of culture and art"

The designer, then, possessing these qualifications may reasonably hope to attain to a position of some eminence in his business; and for any one possessing a fair amount of

taste and common-sense, it is not one of the most difficult tasks to acquire sufficient practical knowledge of the business to enable him to become a designer. Undoubtedly if he has had an early training in the departments of textile manufactures he possesses inestimable advantages over one who has not had such training, because there are in the manufacture of fancy textile fabrics technical details, as in every other business, which can only be acquired by practice, and sometimes only by the aid or advice of those intimately acquainted with the business.

The learner having acquired a facility in sketching simple objects, if he intends to fit himself for designing patterns beyond the simplest kind, will derive much advantage in his early progress by making a collection of simple objects from nature, such as leaves, flowers, &c., which may be copied from drawings or sketched from the originals; and after making himself thoroughly acquainted with their peculiarities of form and colour, begin to modify their forms and conventionalise them, arranging them in every conceivable form which his fancy may dictate, observing at the same time a definite system of arrangement, and paying due attention to symmetry and proportion. He will find that he will be able to give diversity to his designs, and produce rich and novel effects, which can be utilised for the purposes of his business, with both advantage and credit to himself.

Patterns for textile fabrics are generally drawn first on plain paper, to the size which they are intended to occupy in the cloth, and are also coloured, for the purpose of seeing what the effect will be. They are then transferred to the ruled design paper, and enlarged according to the number of threads per inch of the cloth in which they are intended to be woven. This can be easily ascertained. Suppose the pattern is desired to be drawn upon design paper, to appear in a cloth having sixty threads per inch, exactly of the same

size as in the sketch made. Enclose the figure in a square. This square measures, say, three-quarters of an inch in length, that is, the weft way, by half an inch in width. That represents forty-five picks of weft, and thirty threads of warp upon which the entire pattern must be made. Then take a sheet of design paper, and mark off the requisite number of threads each way, and enlarge the sketch proportionately throughout. The sketch may then be coloured as desired. Care must always be taken in colouring designs to fill the small squares round the edges of the design with colour, otherwise, when cutting the cards, it is difficult to see which of the squares are comprised in the figure, and if not correctly read off, the edges of the figure are liable to be jagged, and far from satisfactory. For those who may not be very expert at drawing, it is no easy matter to enlarge an intricate figure, or one in which delicate lines occur, and to preserve perfect symmetry throughout, although it is of the utmost importance that it should be preserved. For such as are placed in this position, considerable advantage may be derived from adopting a method of lining the pattern in squares to correspond with the large squares of the design paper. This will serve as a most reliable guide to them, and enable them to enlarge their design with accuracy and despatch. If the pattern has to be copied from some drawing or fabric which may not be subjected to this operation, then take a tracing of the figure, by means of tracing paper, which place upon a sheet of white paper, and line as desired.

The system of lining or ruling sketches may be practised with advantage even by those who possess some ability as draughtsmen, because enlarging a drawing to the extent to which it must necessarily be enlarged upon design paper, for its reproduction in cloth, requires not only considerable skill as a draughtsman, but good judgment, and a quick and correct eye in discerning form and proportion,

otherwise the figure, when reproduced on the fabric, may be very different in appearance to what is intended.

Then suppose the figure to be reproduced is of the proportion just mentioned, viz., three-quarters of an inch in length by half-an-inch in width, and that it is to occupy forty-five picks, and thirty threads. Then if the design paper upon which the design is to be made is ruled what is known as 8 by 8—that is, that each large square represents eight warp threads and eight picks of weft—the pattern will occupy five large squares and five picks, or $5\frac{5}{8}$ squares one way by three squares and six ends, or $3\frac{3}{4}$ squares the other way. Divide the small sketch exactly to those proportions, and rule lines across it both ways, which will divide the figure into the exact proportions it will occupy on the design paper, or, in other words, the large squares of the design must be made exact counterparts of the squares of the sketch. By this means the exact forms and proportions may be preserved without much difficulty, and large and elaborate figures may be reproduced with comparative ease, and the most satisfactory result.

In case one is dealing with a piece of fabric or other material which cannot be lined, or which could not be traced without considerable difficulty, the material may be laid upon a piece of thick paper or cardboard, and white or coloured threads stitched across it, to represent the squares, instead of pencil or other lines. A very little experience will enable the student to judge at a glance which will be the readiest and best plan to adopt.

There are various kinds of design paper, each ruled to suit the quality of the fabrics for which it may be desired. The kind most generally in use is ruled 8 × 8. In all paper intended for Jacquard designs the number of lines in the warp way must be made to correspond with the number of wires in a row of the machines. The majority of Jacquard's machines are made with eight hooks in a row,

but if the machines are made with twelve instead of eight in a row, as is frequently the case with those containing 600 wires, then the paper must be in twelves the warp way.

Then the variation in the number of lines per square must exist in the weft. For instance, if the relative number of threads of warp and weft is as 8 to 6, then the paper must be 8×6; if, on the other hand, the proportion is as 8 to 10, then the paper must be 8×10, and so on. Any other number must be dealt with in the same way, always taking the number of wires in a row as the basis of the warp, and the relative proportion of weft to warp on that basis will give the paper required.

It is quite as necessary that this matter of the paper should be attended to as the correct drawing of the pattern. Supposing the pattern were drawn upon paper 8×10, and woven upon a cloth the warp and weft of which were as 8 to 6, the pattern would be elongated to nearly double its natural length, and would produce a far from pleasing effect.

Then these rules being duly attended to, the one thing which remains is for the designer to suit his design, whether it be in the form of a figure, stripe, or check, first, to the nature of the material with which he is dealing, and secondly, to the purpose to which the fabric is to be applied. In putting the nature of the material as a subject to be considered before the object to which the article is to be applied, it may appear to some that I am placing the wrong consideration first, or giving too great prominence to it, but a little acquaintance with the manufacture of textile fabrics will soon convince one of the necessity of this arrangement. It may be a very easy matter to arrange a design which would meet all the requirements of the purpose to which the fabric is intended to be applied, but it might be found a very difficult matter to apply the design, or to produce it in a fabric of which the material is not

suitable. For instance, if we are dealing with strong firm threads, such as cotton or worsted, we may introduce a considerable amount of plain working, and at the same time have a considerable quantity of material in the fabric; but if we apply the same design to woollen threads, which possess a totally different character, we may find that not only shall we have considerable difficulty in making the cloth, but if we succeed in making it the result will in all probability be most disappointing. Again, we may have a design which produces a splendid effect upon a silk fabric, but in any other material the result is altogether disappointing, and this may arise either solely from the lustre of the silk imparting a liveliness to the design which no other material could give, or it may arise from the lustre and the fineness of the fabric combining to give character to the design.

This would apply in numerous cases, therefore it becomes necessary that the first consideration should be the nature of the material with which we are working, and in all cases we may be guided by this rule, that the firmer and stronger the thread (especially of the warp) the more firmly and closely it may be interwoven, the softer and more fibrous the thread and the more loosely it must be interwoven; consequently, if a firm cloth is desired, the absence of firmness in the interweaving will have to be compensated for by increased bulk in the thread.

After having determined by the nature of the material the character of working which may be introduced into the design, it may readily be adapted to the purpose for which it is intended to be used. In the selection of forms and objects for designs care should be taken not to violate the recognised rules of art. Wherever natural forms can be introduced they ought to be, but it is a very difficult matter in some classes of fabric to deal with natural forms; but even when dealing with conventionalised forms due

attention should be paid to variety. Even in cases where form can scarcely be said to exist variety may be obtained. If, for example, we are making twills, which in reality are nothing more or less than straight diagonal lines, considerable diversity may be given to the pattern by varying the breadth and character of those lines; and that variety may be further increased by the introduction of figuring between the lines, either for the purpose of concentrating or dispersing the light. In designs for textile fabrics, as in every other composition, there must be the proper play of light and shade, and a due regard to the proper grouping of the figure. If the design be scattered over the surface of the fabric in small, almost imperceptible, patches, the appearance will be spotty and unpleasant, just as if the light and shade of a picture were scattered and unconcentrated; but if the grouping of the figure be so arranged as to present to the eye masses of light and shade, with a due regard to detail, and if the masses of figure are properly interspersed with ground working, and the flat ground broken up with figuring, then the effect will be good, just in the degree in which they balance each other. And whether we are dealing with large elaborate designs, which not only embrace great variety of forms, but also variety of colours, or whether we are dealing with small simple spots or twills, or any other simple form of working, the same principles will apply. In like manner, if we are dealing with stripes or checks, whether the stripes consist of a great variety of colours or simply of one or two, the same principles will apply; and on the success in the application of these principles entirely depends the success of the designer or manufacturer.

I may now call attention to another subject, which is often asource of much embarrassment to beginners, viz., stripe patterns which contain more warp per inch on some portions of the cloth than others, being so fine in the

sett as almost to preclude the possibility of ascertaining the exact pattern which is worked upon it. We will take, for example, a class of stripes which is very much used for ladies' dress goods in various materials, also for stripes for borders of alpaca umbrellas. These stripes we will suppose to be made with a plain ground cloth, the striping being composed of fine material, and very close in the sett. If the stripe be worked as a satin it will present a smooth flat surface, showing nothing but the warp on the face, the weft being entirely hid. In all probability the student would be entirely at a loss to ascertain how it was worked, and even if he suspected that it was a satin he would spend considerable time in trying to find out what satin it was, and unless he was endowed with considerable patience his endeavours might be given up in disgust, only to be renewed again after he had settled down and composed himself somewhat. In a case of this kind it is very easy to ascertain at a glance the exact working almost. If it is a satin the surface will be even and smooth, shewing no pattern, or if any pattern should be visible it will be in the form of a very fine twill, running not at an angle of forty-five degrees or thereabouts, as in an ordinary twill, but it will run nearly in a straight line with the warp threads, partly owing to the closeness of the warp threads, but mainly to the nature of the working. Then, to ascertain the particular satin, take the outermost thread and count how many picks of weft it passes over before it is interwoven with a pick. Supposing it passes over seven and is interwoven at the eighth pick, then you may conclude at once that it is an eight-thread satin, and arrange your pattern as shown at page 183, Fig. 98. Suppose it passes over nine threads, and is interwoven at the tenth, then it is the ten-thread satin, and so forth.

So far as the actual working to produce this goes, if the reader has followed carefully the instruction given in the

foregoing chapters, he will have little diffculty in ascertaining this, the ground warp and the stripe being worked upon two separate sets of healds, a pair of plain ones for the ground, and whatever number is required for the striping. Fig. 285 is a design showing the arrangement, the plain healds being bracketed together and marked A, and the stripe healds bracketed and marked B, the drafting being shown; the threads bracketed together and the remark "twenty-four times" meaning that this portion of the draft must be repeated twenty-four times, making forty-eight threads, and the stripe being repeated nine times, the ground warp being two in a split and the stripe six in a

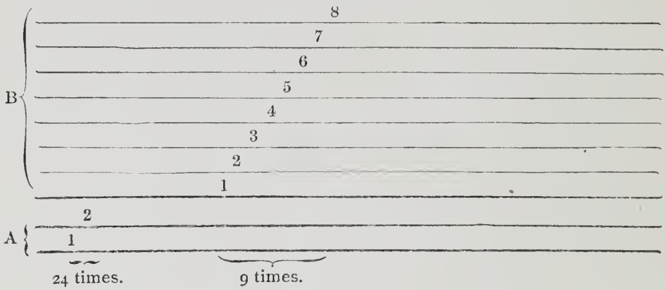


Fig. 285.

split of the reed. The design, Fig. 286, will be the working design for it. Another matter of detail which may be mentioned here, in connection with this particular kind of stripe, is the calculation for the quantity of warp that will be required for each portion. Suppose the reed has sixty splits per inch, the simplest and easiest manner is to take the number of reeds in the width of the piece, and divide that by the number of reeds in each pattern, which will give the number of patterns in the width of the piece. As an example we will take the above pattern, which occupies thirty-three reeds. Suppose the reed to have forty splits per inch, and the piece thirty-three inches wide, the number of splits is 1320, ÷ 33 splits gives 40 patterns in the

width of the piece. It is then easy to ascertain the number of threads in both the ground and the stripe warps. There are 48 threads per pattern of the ground warp ; 48 threads multiplied by 40 patterns gives 1920 threads for the ground warp ; then 72 threads by 40 patterns gives 2880 threads for the stripe warp. This system of calculation also applies to all patterns where one portion of the warp is more crowded in the reed than another portion.

To return to the question of patterns. If it is desired to copy patterns, I should advise a course of procedure here which is perhaps at all times the best, that is, not to attempt to dissect the pattern thread by thread, as is

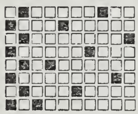


Fig. 286.

sometimes the practice, but to take the pattern off the face of the cloth. It might be said that by doing this it will be almost impossible to obtain an accurate copy, but I venture to say that if the student practises this method, after some little time he will be able to copy patterns with quite as much accuracy and very much quicker than if he attempts to dissect it. The first requisite is that he should make himself thorough master of twilling, both straight and broken, and all the various kinds of working, and treat them as the alphabet of designing ; by doing this he will very seldom make a mistake in arranging a pattern.

SLAYING OR SETTING FABRICS.

The slaying or setting of warps are terms used to denote the proportioning of the counts of warp to the different sets of slay, so as to preserve a uniformity of fabric in similar species of cloth. In consequence of the different methods of indicating or calculating setts of reeds and counts of yarn in different localities it is a difficult matter to deal with this branch of the subject in a satisfactory manner. If a table of calculations were given suitable for the trade of one locality it would not be of the slightest value to those engaged in the staple trade of another locality, so that the subject can only be dealt with on general principles.

In order to explain more clearly what is meant by setting, suppose a piece of cloth is woven in any sett of reed, say, for instance, with forty threads per inch, and that the diameter of the warp threads and the spaces between them are the same; then, if we have another piece of cloth with sixty threads per inch, in this also the diameter of the warp threads corresponding with the intervening spaces, the texture of these two cloths is similar, and they are equally balanced, although the one is so much finer than the other, so that when the diameter of the thread is greater than the spaces, the fabric is proportionately stouter, and when the diameter is smaller it is proportionately thinner.

Then the method of determining the several thicknesses of yarn which will suit a given sett, or the sett which will suit a given yarn, may be said to depend on the following theorem: As the square of any given sett of reed is to

the thickness of yarn that suits that reed, so is the square of any other sett of reed to its respective yarn for the same class of fabric.

The reason of this will appear evident if we consider the threads of warp when stretched in the loom as so many cylinders of equal length, and the reed as the scale which measures the space in which a given number of these threads are contained; therefore the solidities of the thread in one sett of reed will be to the solidities of the thread in any other sett of reed as the squares of their diameters.

But the weight of the threads, supposing them to be of the same density, will be as their solidities, and a determinate number of splits of any reed may be substituted for the diameter of the warp threads; therefore, by this analogy, it will be as the square of the number of splits of any given reed is to the known weight or thickness of the yarn, so is the square of any other number of splits occupying the same space to the weight or thickness of the yarn that will produce the same fabric.

At first sight this may appear very intricate, and difficult of practical application, but on careful examination on the part of the reader it will be found to be strictly true, and exceedingly valuable in the manufactory.

There are numerous rules and formulæ in use in different districts for determining the setting of warps in the slay, but many of these are of an arbitrary nature. One will frequently meet with individuals who have rules of their own, drawn from their own experience, and which are perfectly applicable to certain classes of cloths, but which might be utterly inapplicable in other cloths. Indeed, what may produce in one class of cloth as near perfection as it is possible to arrive at may be seriously detrimental to another class of cloth. But the theorem just laid down will be found applicable under any circum-

stances, and the manufacturer having found what reed and yarn are best adapted for a certain fabric, may with the greatest ease and utmost certainty vary his reed, and always be sure of having the proper yarn to suit it, or vary his yarn and be sure of having the proper reed for it.

Since this was written I have investigated the subject at length, the result of the investigations being given in my work on "Textile Calculations and the Structure of Fabrics."

In close connection with, in fact as a part of, this subject is what is commonly called the "balance of cloth." This is a term which is capable of a wide interpretation. The general interpretation which is put upon it is the proportion in which the warp and weft stand to each other. But if definite rules were laid down, according to this interpretation one cloth might be perfection, and another cloth, according to the same rule, might be anything but perfection. Yet to all appearance, and for the different purposes to which they were to be applied, and according to the principles upon which the two cloths were constructed, one might be as perfect a sample of a cloth as the other. Again, the interpretation may be a wider one, and it may be said that a properly-balanced cloth is one in which the warp threads are set at a certain distance from each other, according to their diameter and weight, and the proportion of weft to warp which existed in the cloth. This interpretation would be a perfectly correct one, and might be carried out in its entirety, but the particular distance of the threads from each other, or the proportion of weft and warp, which might be taken as a basis, could only be taken for the one particular class of fabric to which it applied, because, although that proportion may be all that could be desired for one fabric, experience teaches us that it could not be so for all fabrics, therefore no fixed rule could possibly be laid down which would be applicable to all cases, but the rule being found for any one class of fabric

it would be applicable to all fabrics of that class. Suppose we are dealing with a plain cloth, in which the warp and weft are both of the same material, and that the warp is so set in the reed that the diameter of the thread and the space between the threads are equal, the weft threads are equal in thickness or counts to the warp threads, and there are the same number per inch both ways. Then the cloth may be truly said to be equally balanced, and whether the material be woollen, cotton, or linen, the cloth will be perfect in its construction, and will be made on the truest principle. As will be found pointed out in the work just referred to (page 150). Some little allowance must be made for bending of the threads, but this is the theoretical starting point. But it frequently happens that to produce special effects this principle must be departed from. For instance, it may be desired to produce a corded effect, the cord to run either lengthwise or across the piece, then a different method of balancing must necessarily come into operation. We will suppose we wish to make a poplin, in which it is desired to have a decided cordy character, the cords running across the piece; instead of the warp threads having a space between them equal to the diameter of the threads, they must be set very closely together, and the weft threads must be some distance apart, otherwise the clear cord could not be preserved. But although it is necessary that the weft threads must be some distance apart, that distance must not be too great, or the cord will again be destroyed. Then from this it must be concluded that the warp threads must be set as closely as possible without being too crowded, and the weft threads must be driven as close together as the crossing of the warp thread will permit, and the more carefully this is observed the more perfect will the appearance of the cord be, and this will be materially increased if the weft be proportionately thicker than the warp. But it having been determined

what sett of reed for a given count of yarn will produce the best result, it is easy to determine what reed will suit any other count of yarn to produce the same result. Then suppose that the cord, instead of running across the piece, is intended to run the length of the piece, the procedure will be the reverse of the previous one; that is, the warp threads must be further apart, and the weft as close together as possible, and if the bulk and distance apart of the warp threads be increased, and the bulk and distance apart of the weft threads diminished in a proportional degree, the clearness and boldness of the cord will be increased accordingly, so that in both cases the proposition laid down will hold good.

From those two examples another conclusion must be drawn. In the first the warp preponderates largely on the surface of the fabric, and in the second the weft preponderates; and we have seen that as the warp or the weft preponderates it must be increased in quantity, and that which is least seen must be decreased in quantity (that is in the number of threads per inch). This rule holds good not only for plain cloths but also for any other make of cloth. If we turn, for example, to twilled cloths, in which the same quantity of warp and weft are visible on the face, and in which the warp and weft are of the same material and thickness, then the same rule applies as in plain cloths, that there should be the same number of threads, per inch one way as the other. But twilled cloths differ very materially from plain cloths in this respect, viz., that from the very construction of the cloth the threads must be closer together for the same thickness of thread than in a plain cloth, because in a plain cloth the warp and weft threads cross each other, and are interwoven at every pick, whereas in a twill cloth they may pass over a number of threads before they are interwoven; therefore, the greater the number which are passed over between the interweaving,

the closer or thicker the threads must be to produce an approximate firmness of texture. Hence it is that twilled cloths are so much better adapted for producing heavy, bulky fabrics.

In making twilled cloths the warp or the weft may be made to preponderate on the face of the fabric in two distinct ways. First, in the same manner as in plain cloths, by bringing the warp threads closer together and putting in fewer picks, at the same time decreasing the thickness of one thread and increasing the thickness of the other, or by increasing the distance apart of the warp threads, and putting more picks, again increasing the bulk of one and decreasing that of the other. Second, by bringing one or the other more to the surface in the order of working. In the latter case the rule must be invariable, that, whether the warp or weft preponderates on the face in the working, it must also preponderate in a like degree in the number of threads per inch, or in the actual quantity of material, and it is only when that is done that the cloth can be properly balanced. We can have no better illustration of this rule than in some of the best examples of satin cloths, in which the rule will be found to be observed to the last degree. In any cloth in which this is not done, not only will the cloth have an unpleasant appearance, but the effect of the pattern is marred considerably also.

These observations apply more especially to fabrics in which the warp and weft are of the same material, but they apply also to fabrics in which the warp and weft are of different materials; in the latter case, however, attention must be paid to the nature of the materials, their density, and their adaptability to blend or assimilate with each other, because the relative proportion of warp and weft, thickness, ends per inch, &c., in one material may be quite correct, if both warp and weft are the same, but if the warp be of one material and the weft of another, then a decided change

may take place in their combination. Not only will this be so if one of the threads be vegetable and the other animal substance, but it may be equally so if they are both either animal or vegetable. The combination of a woollen thread with a cotton thread would produce a very different effect from the combination of worsted with cotton, although in both cases it is a combination of animal and vegetable. Again, silk is an animal substance, yet it will require totally different treatment from any other animal fibre in this respect. Therefore absolute rules cannot be laid down, though the general principles may be clearly defined. Guided by these principles and careful observation, the designer or manufacturer will be able to obtain sufficiently reliable data to guide him with tolerable certainty to the best result in his own department, and it is only by observation and experience that these results can be arrived at ; but they are results which no one need despair of achieving.

CALCULATIONS OF MATERIALS, &c.

An important branch of the manufacture of textile fabrics is a knowledge of the system of calculating the material used in the production of a fabric, so as to estimate the cost of the article before offering it for sale.

This is a branch of the subject with which there is some difficulty in dealing satisfactorily, this difficulty arising from the numerous systems of calculation in use in the different manufacturing districts in this country. To some extent this difficulty is met in the little work referred to in the last chapter. It may almost be said that every manufacturing district in Great Britain has a different system of calculating. This diversity of systems applies not only to the methods of counting or weighing yarns, but even in a greater degree to what are termed the setts of the reeds or slays. How these different systems have originated it would be difficult to tell, and in some cases it is not easy to find even upon what they are founded. Supposing we inquire first into the system of calculating the sett of reeds. The most intelligible system in use is that of counting by the number of dents per inch, or the number of threads per inch. The latter is preferable, though either system is sufficiently intelligible. If we reckon by the number of threads per inch, whatever that number is, that is termed the sett. For example, if a cloth contains sixty threads per inch, it would be said to be a sixty sett cloth. On the other hand, if we count by the dents or splits, each split is supposed to contain two threads, so that on this system a cloth containing sixty threads per inch would be termed a thirty sett cloth. This latter system is used in some of the cotton manufacturing districts of Lancashire, and is gene-

rally known as the Stockport count. It is also used in some of the woollen manufacturing districts. Then again, another system which is in use in Lancashire is known as the Manchester and Bolton counts, and is based upon the number of beers in $24\frac{1}{4}$ inches. In other districts we shall find other systems at work. In some cases the number of ends in a beer are thirty-eight, in others forty, in others again they are fifty (the beer is also variously named, in some districts being called a porter or a portit). Then, in addition to the number of ends in the beer varying, the width upon which the calculation is based varies. In some districts it will be 30 inches, in some $24\frac{1}{4}$, as we have seen, in others it will be 36, 38, or 40 inches, according to the class of goods which are being made, and instead of the term sett being used, the cloths are termed so many porter (as say 40-porter) cloths. We shall find other districts calculating by the foot or by the yard. In the Scotch system the sett of the reed is based upon the number of dents or splits in 37 inches; 37 inches is the old Scotch ell, and this is taken as their standard. For instance, if the reed contains 1400 dents in 37 inches, then it is termed a fourteen hundred reed; if it contains 1200 dents in 37 inches it is termed a twelve hundred reed. In the Bradford worsted manufacturing district a different system prevails. The sett is based upon the number of times 40 ends are contained in a yard of 36 inches. It would be difficult to ascertain how this system has sprung into existence. At first sight it would appear as if it was based upon a similar principle to the Manchester and Bolton counts, 36 inches being taken as the basis instead of $24\frac{1}{4}$, but if so the beer of 40 ends has completely dropped out of existence since the system was founded, as the beer or portie is now universally 50 ends in that district. Another conjecture is that the system may have arisen by the goods being ten per cent. narrower when finished than when they

come from the loom, and consequently the warp threads are proportionately closer, and that by degrees what was formerly the finished sett of the cloth became the sett of the unfinished cloth, which would be equivalent to adding one-ninth to the quantity of warp in the fabric. Then, by this system, whatever is the indicated sett, the fabric contains that number plus one-ninth of the number of ends per inch. For example, what is termed a 54 sett would contain 54 + 6 ($\frac{1}{9}$ of 54) = 60 ends per inch. A 64 sett would contain $71\frac{1}{9}$ ends per inch. In making calculations for warps on this principle, to one not much accustomed to the use of figures these fractions sometimes become very troublesome. For instance, supposing the number of ends are required in a warp for a fabric 68 sett, 28 inches wide, if the ends per inch are first obtained, which would be $75\frac{5}{9}$, then there is the necessity of multiplying the fraction by 28. This may be obviated by multiplying 68 by 28, and then adding the one-ninth to the total, thus $68 \times 28 + \frac{1}{9} = 2115\frac{5}{9}$; or what would be still readier, multiply 68 by 28, add a cipher to the product and divide by 9, which will be exactly equivalent to adding one-ninth; thus

$$\begin{array}{r|l} & 68 \\ & 28 \\ \hline 9 & 19040 \\ \hline & 2115\text{-}\frac{5}{9} \end{array}$$

so that the number of ends is obtained at once without the trouble of a fraction. This system of calculation is rather troublesome to the beginner, as indeed are many of the others also; and what adds to the trouble is the difficulty of obtaining information as to the basis upon which the system is founded. I should in all cases recommend any one engaged in the textile trades, on removing from one district to another, to ascertain at the earliest possible moment, as accurately as he possibly can, the system of calculation which is in use in the district, and as far as he

can, trace it to its source, and he will find that his work will be very materially facilitated, for not only will he know better how to work his calculations, but he will have some reason for what he is doing.

Having all these various methods of calculation before me, it becomes a somewhat difficult matter to deal with the question so as to make it intelligible to any one engaged in a district where the method may be different even from any of the above. The only safe way then is to deal with the matter on the basis of a given number of threads per inch, or a given number of reeds per inch. There is one portion of the calculation which is general, and only one, viz., that it is usual to reckon two threads per split, except where otherwise expressed.

Having now determined a basis of calculation for the reed, before we can proceed any further we must also determine a basis for calculating the weights of yarn. These again differ considerably in different localities, but not to such an extent as is the case with the reed scale. The greatest difference in the mode of calculating weight of yarns are in the woollen districts, the cotton, worsted, and linen calculations being very general.

The general method in the two first of the above-named three materials is by the hank, and in the last-named by the lea. The cotton hank contains 840 yards. This hank is determined as follows:—The cotton reel is generally 54 inches in circumference, 80 revolutions of the reel make one rap, or, as it is called in some places, skein, consequently each rap contains 120 yards. Seven raps make one hank, consequently $120 \times 7 = 840$ yards in one hank. The weight of the yarn is then determined by the number of hanks in one pound weight avoirdupois. For instance, 20s cotton means 20 hanks of 840 yards each per pound. If the cotton is twofold, which is very frequently the case, it is then denominated 2-20s, and the number of hanks per pound

is only half the indicated number, that is, 2-20s contains only 10 hanks per pound, being of course two threads of 20s (the single yarn will be a trifle finer than 20s to allow of the length which will be taken up in twisting bringing it to the proper weight) twisted together, and in this way making two hanks into one.

The worsted hank contains only 560 yards, which is made up as follows:--The reel for worsted is only one yard in circumference, instead of one and a-half yards, as in the cotton reel; the number of revolutions per rap is the same, as is also the number of raps per hank, thus 80 revolutions × 7 raps = 560 yards, and the number of hanks per pound is termed the counts. Then worsted yarn is usually sold by the gross of 144 hanks.

Linen yarn, as before mentioned, is reckoned by the lea The linen reel is 90 inches in circumference, 120 revolutions of which make one lea, which consequently contains 300 yards, and the number of leas in one pound is what is spoken of as the counts, as 60 lea or 40 lea, which means that 60 and 40 leas respectively weigh one pound. Linen, like other yarn, is also made up into hanks, 10 leas making one hank and 20 hanks one bundle.

Woollen yarn is reckoned in a variety of ways. I will take in the first place the Yorkshire skein. This skein contains 1536 yards, which is equal to the number of drachms per watern of six pounds, so that whatever number of yards there is per drachm there are so many skeins per watern.

In one district of the West of England the skein is 320 yards, and one pound the standard weight, so that as many times 320 yards as there are in one pound the yarn is termed so many skein yarn, or as many times 20 yards as there are in one ounce will amount to the same thing. Now, to make a comparison of the two, in what is known

as the Yorkshire skein counts, 30 skein yarn will contain 46,080 yards per 6 pounds, while the West of England count 30 skein yarn will contain 57,600 yards per 6 pounds.

Woollen yarn is also sometimes reckoned by the hank, similar to the cotton and worsted yarns. When that is the case the reel is the one and a-half yard reel, the same as cotton, but it is reckoned one-third heavier, which is equal in effect to making it the same length as worsted, or to put it in another way, 8 hanks of woollen are equal in weight and length to 12 hanks of worsted, thus 24s cotton contains 24 hanks per pound, 24s woollen contains 16 hanks per pound; the 16 hanks of woollen are equal in length to 16 hanks of cotton and 24 hanks of worsted.

There are numerous other ways of reckoning the counts of woollen yarn, but to give the whole of them would be no easy task, and as the foregoing are sufficient to show the principle of calculation, it may be left to the student to adopt for himself the particular system which prevails in his district.

Spun silk yarns are reckoned on the same length and weight as cotton, viz., 840 yards, the number of hanks per pound indicating the counts, but in twofold yarns there is this difference between silk and cotton—when twofold cotton is used only half the number of hanks of the indicated counts are contained in one pound, in silk the full number of hanks are contained in the pound, thus 40s silk twofold contains 40 hanks per pound, instead of as in cotton only 20 hanks, and is usually written 40-2.

Raw silk is generally calculated by hanks of 1000 yards, and the counts named by the number of deniers it weighs. In this, as in the woollen counts, there is some diversity in the customs of the different districts, and there appears to be some little difficulty about the weight of a denier. In the work on the silk manufacture, published in the "Cabinet Cyclopædia," by Messrs. Longman, in 1831,

it is said, "A reel so constructed as that the circumference of a skein wound upon it shall be of a certain known admeasurement, is made to perform a given number of revolutions, usually 400, when the skein is removed and accurately weighed. The comparative weights of silk, whereby their fineness is denoted, are estimated in weights called deniers, 20 of which are equal to 16½ grains." Mr. B. F. Cobb, Secretary of the Silk Supply Association, in his "Treatise on Silk," also gives the number of revolutions of the reel as 400, but the weight of the denier he gives as "200 of which are equal to 16½ grains." Probably the 200 is intended for 20, but it is remarkable that in neither of the two works is the circumference of the reel given. In Macclesfield 530 deniers are equal to one ounce, and 530 yards the standard length to weigh. Again, the denier is often described as equal to two grains Dr. Ure, in his "Philosophy of Manufactures," says he understood it to be equal to 0·693 of an English grain, but upon testing a denier weight he found it to be equal to 0·833 grains. This latter would very nearly approximate to the weight given by the "Cabinet Cyclopædia," which would make the denier equal to 0·825 grains. While Mr. Simmonds, in the Appendix to the "Philosophy of Manufactures," says, "the custom of the trade is to reckon 32 deniers to a drachm, and that the standard of silk measure is about 400 yards; that length of a single filament of China cocoons will weigh two deniers, and of French or Italian two and a-half." If the drachm here mentioned is the apothecaries' drachm, then the weight of a denier would be 1·875 grains; but if it be the drachm avoirdupois, the weight of the denier would be 0·854 of a grain, or a little heavier than the weight found by Dr. Ure, and that given in the "Cabinet Cyclopædia." But the former would nearly approximate to the weight spoken of as "two grains." Which of the two is correct it would not be easy to say; prabobly each may be correct

as used in two separate districts, for, as before mentioned, scarcely any two districts calculate on the same principle. If we take, for instance, against the weights just given the Macclesfield weight, in which 530 deniers are equal to an ounce, if the ounce is avoirdupois, then the weight would be 0·8245 of a grain, or as nearly as possible corresponding with the weight given in the "Cabinet Cylopædia," and by Mr. Cobb; but if the weight be apothecaries' (which is not probable) the weight would be 0·905 of a grain. It may, I think, be pretty safely assumed that the Macclesfield weight is the correct one, more especially as there is some show of reason for it, because 530 yards being the standard length reeled, and 530 deniers being equal to one ounce, whatever number of deniers 500 yards weigh the fractional part of an ounce is at once indicated. And as all the weights given approximate so nearly to this it is probable that they have the same common origin. In this, as in many other things, it will be found that the oldest authorities are the most reliable, because, as years pass on, changes take place, by almost imperceptible degrees, but collectively those changes amount sometimes to an alarming item; and the origin of the system having become lost in antiquity there is no means of checking or remedying them, therefore the nearer we get to their origin the more reliable will our authority be found to be.

Having glanced at some of the various methods of estimating the counts of yarn of different kinds, we may now examine into the readiest methods of ascertaining what is the count of any yarn. There are two distinct methods of doing this, one is by the use of ordinary weights, and the other by the use of weights or apparatus specially prepared for the purpose. One of these apparatus, and certainly a most convenient one, is what is known as the "quadrant." This "quadrant" is a modification of a lever balance, one end of which is made to

assume the form of a quadrant or quarter circle, and is so graduated that when a given number of yards are placed at the other end of the lever a pointer indicates on the quadrant what is the count of the yarn, or how many hanks would be equal to one pound. This is no doubt a very ready method of ascertaining the counts of yarn, but as there are so many different methods of indicating counts there must of necessity be as many different arrangements of quadrant. Then it must be advisable to have some ready method of ascertaining the counts of yarn by the use of ordinary weights. Supposing we are dealing with cotton yarn, we know in the first place that as many hanks of 840 yards each as there are in one pound avoirdupois is the counts of the yarn, but as it may not be convenient to weigh a pound of yarn some other plan must be adopted. One pound avoirdupois is equal to 7000 grains troy, therefore, if we divide 7000 (the number of grains in one pound) by 840 (the number of yards in one hank) we shall obtain a weight which will answer to one yard of length, thus $\frac{7000}{840} = 8\frac{1}{3}$ grains. Consequently if one yard of yarn weighs $8\frac{1}{3}$ grains, one hank of that yarn will weigh one pound, so that as many yards as weigh $8\frac{1}{3}$ grains so many hanks will weigh one pound, or that will be the counts of the yarn. Example: If 20 yards weigh $8\frac{1}{3}$ grains the yarn will be 20s, or equal to 20 hanks per pound. In spun silk the same weight will apply, as the hank is 840 yards as in cotton, the only difference being that already pointed out, viz., that in twofold spun silks there are the same number of hanks per pound as in single yarns, but in cotton twofold yarns there are only half the number there are in singles.

If we are dealing with worsted the same rule will apply, only, that the worsted hank being 560 yards we must divide 7000 by 560 to obtain the standard weight. Thus, $\frac{7000}{560} = 12\frac{1}{2}$ grains, so that as many yards of worsted

as will weigh $12\frac{1}{2}$ grains there will be hanks per pound. By this method it will be found to be a very easy matter to ascertain the counts of any yarn, even if only a very small quantity be available for the purpose of testing. If it be found that sufficient accuracy cannot be obtained by testing so small a quantity (though in the majority of cases a sufficient degree of accuracy will be obtained) then the length reeled may be increased, and the weight increased proportionately. Thus, a rap may be reeled (of cotton or silk 120 yards, of worsted 80 yards), then as one rap is equal to one-seventh of a hank, 1000 grains will be equal to the one-seventh of a pound, so that whatever part of 1000 grains one rap weighs, or whatever number of raps are required to weigh 1000 grains, that number of hanks will weigh one pound.

In estimating the counts of woollen yarn by the wartern, as already pointed out, whether six, seven, or ten pounds be taken as the standard weight, whatever number of yards weigh one drachm, that number of skeins (each skein containing as many yards as there are drachms in the wartern) will weigh a wartern, so that it is an easy matter to ascertain the counts of woollen yarn on this principle.

There is yet one other matter connected with the counts of yarn which requires to be dealt with. In speaking of twofold yarns it has been stated that a twofold cotton, worsted, or woollen would have only half as many hanks per pound as the indicated counts. Thus a twofold forty yarn would only give twenty hanks per pound. In all cases where the two threads which are twisted together are of the same counts it is an easy matter to ascertain the weight the yarn will be when doubled, by simply dividing the counts by two; but when the two threads are not the same it is not quite so easy a matter to ascertain what counts the yarn will be. For example, if we twist a thread

of 44s and a thread of 36s cotton together it would appear as though the counts of the twofold yarn would be just the same as if the two threads were 40s, because one is as much finer than 40s as the other is thicker, as indicated by the numbers. And further, we may say in twofold 40s there are 80 hanks in two pounds, therefore there must of necessity, when the two are put together, be half that number in two pounds, and consequently 20 hanks in one pound; also, if we put 36s and 44s together there will be 80 hanks in two pounds (this would be perfectly correct weighed superficially), consequently there must be when doubled half that number in two pounds, and therefore 20 hanks in one pound, exactly as in twofold 40s. Then let us see what are the facts of the case. One hank of 40s will weigh 6·4 drachms, therefore when two are put together they would weigh 12·8 drachms, or equal to the one-twentieth of a pound. One hank of 36s will weigh 7·11 drachms, one hank of 44s 5·82 drachms nearly, then the two together would weigh 12·93 drachms, instead of 12.8 as in the previous case, consequently the 36s and 44s twisted together would give a yarn having only $19\frac{4}{5}$ hanks per pound. This result may be arrived at by other and shorter methods. I have illustrated by this method for the purpose of showing the reason. Another method is to divide the highest count by each count in succession, and then divide the highest again by the sum of all the quotients, and the answer will be the counts of the yarn; thus, $\frac{44}{44} = 1$, $\frac{44}{36} = 1·22$, then $\frac{44}{2·22} = 19·8$, or $19\frac{4}{5}$, the counts. Another and still shorter method is to divide the product of the numbers by their sum, and the quotient will be the counts of the doubled yarn; thus, $44 \times 36 = 1584$, $44 + 36 = 80$, then $1584 \div 80 = 19·8$, the counts of the yarn.

The same rule will apply if any number of threads be twisted together, and for any kind of yarn. Of course in

all these methods no allowance is made for take-up in the twisting of the threads, as this would vary not only in different yarns, but also in the same yarns, according to the amount of twist which might be put in them, so that the allowance for twist being a variable quantity, it must be left to practice to determine what allowance must be made for it.

Having now glanced over the various methods of reckoning the weight of yarns, we may proceed to give a few examples of calculating the quantity of material required for producing a given make of cloth.

The general mode of procedure is first to ascertain the number of threads in the warp and the counts of yarn, and then the number of picks per inch and the counts of weft.

We will begin first of all with a cotton cloth. We will suppose the cloth to be 24 inches wide, and to contain 1600 threads of say 2-60s warp. The length of warp is 60 yards to make a 54 yard piece; then the calculation will be as follows, $1600 \times 60 = 96{,}000$ yards. This 96,000 yards divided by 840 yards per hank, $96{,}000 \div 840 = 114\frac{2}{7}$ hanks, which being 2-60s (or equivalent to 30s) is a fraction under 3 lbs. 13 oz. weight. Then as to the weft; the cloth is 24 inches wide, and has 60 picks per inch of 1-20s cotton weft. If the width of the piece be multiplied by the picks per inch it will give the number of inches of yarn required to make one inch of cloth, which of course will be equal to the number of yards required to make one yard of cloth, thus $24 \times 60 = 1440$ inches of weft in one inch of cloth, or 1440 yards of yarn in one yard of cloth. The piece is 54 yards long, then $1440 \times 54 = 77{,}760$ yards of yarn in the piece. Then $77{,}760 \div 840 = 92\frac{4}{7}$ hanks of 1-20s, gives 4 lbs. 10 oz. of weft, or a total weight of cloth of 8 lbs. 7 oz. In calculating the cost of weft 5 per cent. is usually allowed for waste, or sometimes more, according to the quality of the yarn.

We will now suppose that the cloth, instead of being woven with cotton weft, is woven with worsted. Of course, the calculation for the cotton warp still remains precisely the same, and the method of ascertaining the quantity of weft is the same so far as ascertaining the number of yards in the piece. Then, instead of dividing the number of yards by 840 to ascertain the number of hanks, we divide by 560, which is the number of yards in the worsted hank, thus, $77{,}760 \div 560 = 138\frac{6}{7}$ hanks of worsted weft. After adding the percentage for waste the cost may be calculated according to the price per gross, or it may be reduced to the weight and calculated per pound.

The method of calculating for worsted or any other kind of warp is precisely on the same principle. The only difference in calculating for any kind of material consists in the difference in the weight and length. For instance, if we compare the above calculations with a woollen calculation, in the warp we find we have 96,000 yards of thread. Instead of reducing it to hanks, supposing we wish to reckon by the Yorkshire skein, we divide it by the number of yards in the skein, and then by the weight of the yarn (so called) we shall get the quantity of yarn required. Thus, $96{,}000 \div 1536 = 62{\cdot}435$ skeins, then 1536 yards is the representative of one skein for 6 pounds, consequently if the yarn be 30 skein the calculation will be, as $30 : 62{\cdot}435 :: 6 = 12{\cdot}487$ pounds.

If calculating for twofold yarn the same rule must be observed as for cotton or worsted yarn, viz., half the length as for the same counts single, thus 2-30s would only count as 15s, &c.

It would be an easy matter to fill pages with examples of calculations of various cloths and materials, but the few examples here given, if carefully examined, will be found to contain all that is necessary for a general knowledge of the system of calculating for any class of goods, and the

student, after acquiring a knowledge of the principle of reckoning the counts and weights, may easily adapt them to the particular method of counting in his own district, therefore, I shall content myself with giving a few examples of patterns which by reason of the warp not being regular in the slay (as in stripes, where some portion is more crowded in the slay than others) contain more warp than the indicated sett of the slay represents, and other examples which may be said to be outside of the regular system of calculations. It would be a mere waste of time and labour to compile a series of calculation tables, which would not be of the slightest use, except in one particular district.

In making calculations for cloths which are not of the same colour throughout, or where some portion of the cloth is finer or closer in the threads, the work becomes a little more intricate, but still the same principles underlie throughout, and it becomes only a question of proportion in one form or another. Suppose we have a warp consisting of black and white arranged in stripes across the piece, and that the black is present in the proportion of two parts to one part of the white. Then if the warp contains, say 1890 ends, there must be 1260 ends of black and 630 ends of white; or if there are a number of colours present, it will be still a question of proportion; or perhaps the matter will appear in a more practical form if we divide the total number of ends in the warp by the number of ends in one complete pattern; this will give the number of patterns in the full width of the piece. Then multiply the number of patterns by the number of ends of each colour separately, and this will give the number of ends of each colour required in the warp. One thing should be very carefully attended to in arranging stripe patterns, that the two sides of the piece (especially for goods which must be joined side to side when being made up for the purpose to

which they are to be applied) shall be the same, so that if one side be joined to the other no break will occur in the pattern, or if the pattern be for shawls, or for any other material which may not have to be joined together at the edges, the two sides should be made alike for appearance sake, otherwise the piece will look very odd and one-sided. Therefore a little care should always be bestowed upon the arrangement of patterns of this description, so as to preserve this uniformity. That being done, the calculation is as has been pointed out, merely one of proportion. Sometimes fabrics are arranged with one portion of the warp very much finer in the reed than the other portions. Even in this case the calculation is simply one of proportion, but the working is slightly different to the previous case, because not only the number of ends of each colour may be different, but the total number will be affected just in the degree to which the crowding in the reed is carried. Suppose a slay has thirty reeds per inch, and that one portion of the warp is drawn two threads in a reed, and another portion four threads in a reed, the readiest way will be to divide the total number of reeds in the width of the piece by the number of reeds occupied by the pattern, then multiply the number of patterns so obtained by the number of ends in the pattern, or, if there are several colours, by the number of threads of each colour; the product will be the number of threads required. If the cloth is to be 30 inches wide, and there are 900 reeds in the width of the piece; then say the pattern occupies 25 reeds —16 reeds with two ends in each, and 9 reeds with four ends in each — $900 \div 25 = 36$, then 16 reeds with two ends in each will be equal to 32 ends by 36 patterns, or 1152 ends. Then 9 reeds with four ends in each will be equal to 36 ends by 36 patterns, or 1296 ends, or a total of 2448 ends. If the two stripes are of different colours we have at once the number of ends required of each colour; or

if there are a number of colours in the pattern the principle will be the same. In all cases of calculation for warps this method will be found both ready and correct.

If the cloth has to be checked the weft will require to be calculated in a similar manner; first find the total then the proportion of each colour as they exist in the pattern.

There are numerous short methods of calculating adopted by those engaged in the different branches of the trade. It may be worth while to point out one or two of these, but they are not adapted for general practice, and it is not a difficult matter for any one to make a short method for himself, still an explanation of the system upon which some of these short methods are founded may be of some little service to the student. In some cases manufacturers in making their calculation for materials allow a percentage for waste in the calculation, instead of adding it afterwards. For instance, in calculating what weft will be required to weave a piece of a given width and length, and a given number of picks per inch, a certain allowance will be made to cover waste which will be made in weaving, and the natural shrinkages of the yarn. This allowance will be on the average about 5 per cent., in some cases more, in some less; then the calculation is made so as to cover this allowance. A short method may be adopted of making this calculation if the pieces are of one uniform length, say 48 yards. Then a constant multiplier and divisor may be found which will give the hanks with any percentage allowed at once. Suppose we wish to allow five per cent. for waste, multiply picks per inch, width of piece in inches, and nine into each other, and divide by 100; the quotient will be worsted hanks required to weave a piece, with five per cent. added for waste. Thus, piece 30 inches wide, 60 picks per inch, 48 yards long, $\frac{30 \times 60 \times 9}{100} = 162$ hanks. This will be found very ready in

practice, because dividing by 100 simply means placing the decimal point before the last two figures, or, as in the illustration here given, cancelling the ciphers.

The reason why this method gives five per cent. allowance may not be apparent at first sight ; I will endeavour to explain it. If we add five per cent. to 48, the sum will be 50·4. If we multiply 50·4 by 100 and divide by 560 (the yards in a hank) the quotient will be 9, so that having multiplied picks per inch by width of piece, multiplying by 9 and dividing by 100 is exactly equivalent to multiplying by 48 and dividing by 560, and then adding five per cent. In the same manner keeping 100 for a constant divisor, a multiplier may be found for any length, or for any allowance. Warps may be calculated in a similar manner. In some classes of goods the value is estimated according to the weight per square yard, and very frequently only very small samples of cloth are available for calculating from. In cases of this kind the weight and value may be readily found by weighing a square inch. Suppose a square inch weighs 12 grains, then a square yard weighs 35·55 ounces. This calculation is as follows:—Multiply 1296 (inches in square yard) by grains weight of square inch, and divide by 437·5 (grains per ounce); the quotient will be ounces weight per square yard, thus $\frac{1296 \times 12}{437{\cdot}5} = 35{\cdot}55$ ounces per square yard.

Numerous other short methods might be given, but as each would merely apply to the system of calculation in use in any particular district, the above will be sufficient to show the principle upon which they are arranged, and the student will have little difficulty in making short calculations for himself.

COLOUR.

In the manufacture of fancy textile fabrics the distribution and arrangement of colour is of no less importance than a judicious selection and arrangement of patterns, consequently a knowledge of the principles upon which the science of colour is founded, and of the laws of harmony, is of the first importance to the designer.

The science of colour teaches the nature and causes of colours, their distinctions, their relations to each other, their classification, the mental effects that attend them, and the causes and laws of their harmony.

It also includes the modifications of colours arising from varying sensibility of the eye, and the peculiarities of colour visions which are found to exist in different individuals. It enables the eye to distinguish and recognise the different hues in their various tints and shades, and to acquire a correct judgment of the constituents of colours, upon which their effect in any composition depends; it improves and directs the natural taste, and aids the student in arranging as well as appreciating good compositions of colour.

The whole subject is full of interest and beauty, and an acquaintance with it adds extremely to the pleasure to be derived from the contemplation of natural objects and scenery, as well as works of art; and it has one advantage, perhaps, over any other branch of natural philosophy, it teaches us in a remarkable way to distinguish between sensations and their causes, and not to judge hastily according to the appearance of things; and as the chief difficulty of the student of colour arises from this, it is necessary to call his attention specially to it, to guard

against those misconceptions which might otherwise very much retard his progress.

Then, first of all, what does the science of colour teach us? It teaches that colours are simply and purely sensations, excited by the action of light on the nervous tissues of the retina, which forms a screen at the back of the eye; and a little reflection and observation must convince us that they must be so, since they are only seen by the aid of the light and vary considerably with different kinds of light.

But when we look at an object we see so clearly the colour on its surface at a distance from us, and that colour under the ordinary light of day is so constantly the same, that it is difficult to believe it is not some inherent quality of the surface, belonging quite as much to the object as the form which we see, and this belief, which is certainly a common one, is with some persons so strong that it is extremely difficult to make them understand the difference between colours (properly so called) and the colouring matter or pigments which are known by the same names.

To enter fully into the science of colour, and to trace all the sensations to their ligitimate origin, would be sufficient for a volume, and indeed should be dealt with and studied as a science, quite apart from any other subject, before its laws and teachings are applied to any branch of industry; but as it is not possible for every one whose business may cause them to require some knowledge of the laws of harmony to study the subject so thoroughly, it becomes necessary to give the leading features of the subject in as concise a form as possible, thereby enabling them to acquire such information upon the subject as will be of some assistance to them in their daily avocations, and also assist them to a higher appreciation of all the beauties which nature so lavishly displays before them, as well as all that is high and noble in art.

Then, to return to our subject, it has been said that colours are sensations excited by the action of light. Whenever, therefore, the term light is used to express a sensation, it must be understood and accepted as a general term, including each and all of the colour sensations, and when we say that light is composed of certain colours, we intend to convey that under certain conditions it excites one or all of those sensations of colour. For instance, it is said that a ray of solar light is composed of an indeterminate number of variously-coloured rays, which simply means that a ray of solar light has the power of exciting sensations of colour, according to the conditions under which it is presented to the eye, or to the condition in which the eye is prepared to receive it.

These colour sensations may be divided into simple and compound sensations, the eye being so constituted as to be capable of three simple or elementary sensations of colour, except in the case of some individuals, in whom some of the sensations are deficient, this deficiency being commonly known as colour blindness.

These colour sensations are beautifully revealed and may be accurately analysed by means of the prismatic spectrum.

The three simple or elementary sensations are best described and understood by the terms of red, yellow, and blue.

The simple sensations are never excited separately on any part of the retina, but always accompany each other in a greater or less degree, thus causing the endless variety of colour which we observe.

When all are excited at once with an equal intensity on the same part of the retina, the result is the sensation of white.

The theory of colour established by Sir Isaac Newton, and adopted by Sir David Brewster and others, was that

light was composed of seven different colours. The experiments which led to this conclusion were conducted by Sir Isaac Newton in the following manner:—In the window shutter of a darkened room he made a hole about a third of an inch in diameter, behind which, at a short distance, he placed a prism, so that a ray of the sun's light might enter and leave it at equal angles. This ray, which before the introduction of the prism proceeded in a straight line, and formed a round spot upon a screen placed a few feet from the window, was now found to be refracted, appeared of an oblong shape, and was composed of seven different colours of the greatest brilliancy, imperceptibly blended together, viz., violet, indigo, blue, green, yellow, orange, and red. This is what is termed the solar or prismatic spectrum.

The theory thus said to be established was that the white light of the sun is composed of several colours, which often appear by themselves, and that white light may be separated into its elements. Sir Isaac followed up his experiments by making use of a second prism, by making a hole in the screen upon which the spectrum is formed, opposite to each of these colours successively, so as to allow it alone to pass, and by letting the colour thus separated from the rest fall upon the second prism he found that the light of each of the colours was alike irrefrangible, because the second prism could not separate any of them into an oblong image, or any other colour than its own; hence he called all the colours simple or homogeneous.

From this it would appear that light is composed of seven primary colours; but Sir David Brewster, in a communication read to the Royal Society of Edinburgh, in 1831, showed that white light consisted only of three primary colours, red, yellow, and blue, and that the other colours shown by the prism are composed of these. This

theory receives its first suggestion from the fact that each of the other colours are placed between those two of the primaries whose admixture will produce it. A discovery made by Buffon, and frequently illustrated by succeeding philosophers, also tends to strengthen this theory. If we look steadily for a considerable time upon a spot of any given colour, placed on a white or black ground, it will appear surrounded by another colour. This colour will invariably be found to be that which makes up the harmonic triad of the three primaries, red, yellow, and blue; if the spot be red, the border will be green, which is composed of yellow and blue; if yellow, the border will be purple, which is composed of blue and red; and if blue, the border will be orange, which is composed of red and yellow, in all cases making a tri-unity of the three primary colours.

The composition of the secondary colours may also be proved by following out the experiments with the prism. If two of the primary colours be separated from the rest and thrown together by means of a second prism, the result will be to produce the secondary or intermediate colours with as much purity and intensity as in the spectrum.

Another theory, which was originally advanced by Aristotle, and afterwards adopted by Leonardo de Vinci, is that transient colours are more likely to be the result of the action of light upon shade than the separation of light into its elements. This theory has been taken up by Goethe, who gives his opinion in the following terms:—

"Light and darkness, brightness and obscurity, or if a more general expression is preferred, light and its absence, are necessary to the production of colour. Next to light a colour appears which we call yellow, another appears next to darkness which we call blue. When these in their purest state are so mixed that they are exactly equal, they produce a third colour called green. Each of the first-named colours can of itself produce a new tint by being

condensed or darkened. They thus acquire a reddish appearance, which can be increased to so great a degree that the original yellow or blue is hardly to be recognised in it; but the intensest and purest red, especially in physical cases, is produced, when the two extremes of the yellow red and the blue red are united. This is the actual state of the appearance and generation of colours. But we can also assume an existing red, in addition to the definite existing blue and yellow, and we can produce contrarywise by mixing what we directly produce by augmentation or deepening. With these three or six colours, which may be conveniently included in a circle, the elementary doctrine of colours is alone concerned. All other modifications, which may be extended to infinity, have reference to the technical operations of the painter and dyer, and the various purposes of artificial life. To point out another general quality, we may observe that colours throughout may be considered as half lights, as half shadows, on which account, if they are so mixed as reciprocally to destroy the specific hues, a shadowy tint or grey is produced."*

Eastlake observes that the opinion so often stated by Goethe, namely, that increase of colour supposes increase of darkness, may be granted without difficulty. And he also observes, "Aristotle's notion respecting the derivation of colour from white and black may be illustrated by the following opinion on the very similar theory of Goethe:—

"Goethe and Leeback regard colour as resulting from the mixture of white and black, and ascribe to the different colours a quality of darkness by the different degrees of which they are distinguished, passing from white to black through the gradations of yellow, orange, red, violet, and blue. This remark, though it has no influence in weakening

* "Goeth's Theory of Colours," translated by Eastlake. Introduction, pp. xlii. and xliii.

the theory of Newton, is certainly correct, having been confirmed experimently by the researches of Herschel, who ascertained the relative intensity of the different coloured rays by illuminating different coloured objects under the microscope by their means.

" 'Another certain proof of the difference in brightness of the different coloured rays is afforded by the phenomena of ocular spectræ. If, after gazing at the sun, the eyes are closed so as to exclude the light, the image of the sun appears at first as a luminous or white spectrum upon a dark ground, but it gradually passes through the series of colours to black, that is to say, until it can be no longer distinguished from the dark field of vision, and the colours which it assumes are successively those intermediate between white and black, in the order of their illuminating power or brightness, viz., yellow, orange, red, violet, and blue. If, on the other hand, after looking at the sun for some time we turn our eyes towards a white surface, the image of the sun is seen at first as a black spectrum upon the white surface, and gradually passes through the different colours, from the darkest to the lightest, and at last becomes white, so that it can no longer be distinguished from the white surface.' " *

These authorities may be considered sufficient to warrant the adoption of the theory that shade as well as light acts in the production of transient colours, or, in other words, colour is produced by the action of light upon the retina, the quality of the colour being determined by the conditions under which it is presented to the eye.

Having examined the causes of colour, or rather the conditions under which colour is seen, we may now proceed to examine colours generally and divide them into the classes to which they belong.

* "Elements of Physiology," by J. Müller, M.D. Translated from the German by William Bailey, M.D., London, 1839.

There are only three classes of colour, and they are termed primaries, secondaries, and tertiaries, or hues.

A primary colour is a simple element that cannot be separated into parts, but may be reduced to a tint by white, or to a shade by black. The admixture of either of the other two primary colours changes it to a secondary colour.

A secondary colour is consequently produced by the combination of two primary colours. The secondary, like the primary colours, may be reduced to a tint by the admixture of white, or to a shade by black, and may also by the subordination of either of their component parts be changed in tone, still generally retaining their name, with perhaps the addition of the name of the primary which predominates prefixed, as blue-green, &c. Hence arise an immense number of modifications of each of the secondary colours; of green from the yellowest to the bluest; of orange, from the yellowest to the reddest; and of purple, from the reddest to the bluest.* A secondary colour cannot be changed in character, but by the admixture of its contrasting primary, or by its combination with one of the other secondaries, it becomes a tertiary or hue.

As a tertiary colour or hue is compounded of two secondary colours, and is consequently a mixture of three primaries, therefore it may be modified in tone to a much greater extent than either primary or secondary colours, such modifications being effected by the predominance or subordination of any of its component parts, as also by the power of neutralisation possessed by each of those parts upon the other two. Of these hues three may be taken as primary hues, as follows:—Olive, produced by the mixture of purple and green; citron, by the mixture of green and orange; and russet, by the mixture of orange

* It is only right to say here, that the red, yellow, and blue theory is said by most of our eminent scientists to be exploded, yet in practice, there is no doubt it is the one upon which most people work, and certainly work satisfactorily; and for this reason has been adhered to here.

and purple, These hues are all produced by the combination of the three primary colours, which neutralise each other, the most neutral of hues being grey, the mean between black and white, or the mean between light and darkness, as the secondary colours are between two of the primaries. This colour may with propriety be termed the seventh colour.

Tertiary colours stand in the same relation to the secondaries as the secondaries do to the primaries.

From the tertiary colours given above, and which I have called primary hues, by repeating a similar process of combination and proper balancing of their relative powers, arise the secondary hues, which are known by the name of brown, maroon, and slate.

Then, having determined the primary colours, and by their combination produced the secondary, and again in turn having combined the secondaries and produced the tertiary, it remains to show the relation which these respective colours bear towards each other, and to examine the laws of contrast and harmony.

Having shown that white light is composed of three primary colours, it must be evident that if a colour which is the result of a combination of two of these primaries, or if a series of colours in which one of the primary colours is absent be presented to the eye, the sensation produced cannot be perfectly harmonious, being of an imperfect character, consequent upon the absence of this primary element. Thus, if green is presented to the eye, green being composed of blue and yellow, the primary element which is absent is red, consequently red is said to be the complementary colour of green; orange being composed of red and yellow, blue is the complementary colour of orange; and purple being composed of blue and red, yellow is the complementary colour of purple.

Before proceeding to deal with the laws of harmonious

colouring it may perhaps be as well to glance at the laws of contrast. As the eye glances backwards and forwards from one part of an object to another, the consequence of the variableness of its sensibility is, that the different colours of neighbouring parts more or less modify each other. For they are sure to be some mixture of the three primary sensations, and the proportion must become altered according to the nature of the previous excitement of the eye.

These modifications are commonly termed the effects of simultaneous contrast, the general effect of which is to make the difference of two colours in brightness and hue appear greater than it really is.

If we look at the same time at two stripes of unequal tints of the same colour, or at two stripes of equal tints of different colours, placed side by side, if the stripes are not too wide; certain modifications of the sensations will take place; in the first case the intensity of the tints will be affected, and in the second a modification of the composition of the two colours. Thus bright white subtracts whiteness from any contiguous objects, and causes their colours to appear darker and deeper than they really are, but without in any degree altering their hues. In like manner, if red and orange be placed together the red will take red from the orange and make it appear yellow. Dark green will subtract from light green, strong blue from blue, &c. On the other hand colours placed together which are complementary to each other tend to increase their intensity. For instance, red is the complementary of green; if they are placed side by side both colours are increased in intensity by the contiguity. If orange and blue be placed together the same result occurs, and so on throughout the scale of colours. This result may be easily understood. We have only to remember for a moment that white light is composed of the three primaries, consequently any one of the primaries will reflect its own rays

and tend to create in the vision the rays of the other two, and any of the secondaries will reflect the rays of the two primaries of which it is composed, and tend to create the rays of the primary which is complementary to it. Thus green will tend to create red rays, and red will tend to create green rays, so that when placed in juxtaposition the result is to heighten the effect of both colours by the tendency of each to create the rays of the other.

Black of course seems to brighten white, and to make all other colours appear lighter and clearer in the same manner as white makes them appear darker.

Harmony of colour is one of the greatest sources of beauty, and that harmony of colour is guided by definite laws there can be no doubt, for if various colour compositions of like character are compared, no matter whether they consist of different colours, or of the same colours differently arranged, it is seen at once that some are more pleasing than others, and in whatever form we contemplate colour, whether in nature or art, the majority of those who see colours alike are quite agreed in the objects of their preference.

Colour compositions are endlessly varied in character. They may be composed of two or three colours, or they may be composed of many. The colours may meet in sudden contrast, or they may blend into each other by imperceptible gradations. The different hues may be bordered with other hues, or with white, grey, or black. The colours may be of the deepest or the lightest possible, or they may be nearly neutral in hue. They may be dark or light, or they may be a mixture of all sorts, and as some of these are found to excel in beauty, it would seem then that harmony consists in something independent of all accidental circumstances.

Certain rules for producing this harmonious arrangement of colours may be laid down. We have endeavoured

to point out the necessity for the presence of all the primary colours in any composition, but those colours must only be present in certain quantities, as the circumstances under which they appear will permit. Then, first and foremost, this pleasing composition must have a leading feature, and some one of the colour sensations excited to a slightly higher degree than the rest, so as to give to that colour a force or prominence in the group. There is no doubt that the excitation of each colour sensation is attended with a certain degree of pleasure, but its cessation becomes necessary after a certain interval, and as the eye leaves this colour it must be directed to some other. In contemplating a colour composition the eye is almost unconsciously directed to its different parts in succession. The colour sensation becomes affected or relieved, according as the object sends or does not send to the eye the rays which excite such sensations, so that a composition which is complete in itself should affect the eye with all the colour sensations either jointly or separately, and in such degree as to preserve the tone of the composition. Each colour sensation must be relieved also at proper intervals, which relief may be easily afforded by the introduction of black, or by one or more shades intervening, or by regular gradations, the rule being observed that the darker any colour the less it will require relief.

Colours which are nearly related to each other, none of which excite the colour sensations to a much higher degree than the others, always produce a good effect when placed in juxtaposition. Thus very dark colours, whatever their hue, are all congruous with black and with each other; in like manner very light colours, whatever their hue, are all congruous with white and with each other. This may very easily be proved by reference to nature, where associations of this description are very common. Take, for instance, the gradation of shades from crimson to pink in roses,

arising not only from the different colours of their parts, but also from the reflections produced between the petals, and in numerous examples to be met with in every-day life,

Colours which differ mainly in light and shade, whatever their hues, always associate well, and have a good effect when placed in juxtaposition, especially if the quantity of unneutralised light contained in both of them is but small.

Thus complementaries, and other colours which differ widely from each other in hue, may very frequently be placed in juxtaposition, and with great advantage if these conditions are observed, such, for instance, as a deep primary and its opposite pale, clear secondary. The most striking contrast between colours of different hues in nature are of this character, as in flowers, between the yellow and purple of the pansy, and the dark blue and light crimson in some kinds of fuchsias.

But if bright colours which are complementary to each other, or differ widely in hue, are placed in juxtaposition, the effect in general is not of such an agreeable character. There is generally a certain harshness in the association of such colours, which is commonly called a discord, caused doubtless by the difficulty experienced by the eye in accommodating itself to the sudden change from one powerful predominating hue to another. When colours of this kind come together in a composition in large quantities it is difficult to avoid a glaring effect, but they may sometimes be used together in small quantities with a good effect, provided they are accompanied by neutralising colours. In all compositions of colour there should be some degree of accordance between the breadths of the spaces occupied by the different colours in the composition. These breadths should be such as the eye is capable of viewing distinctly and with satisfaction, (taking into account the distance from which it is probable it will in general be viewed)

without changing its direction more slowly or more quickly than is usual in contemplating an object.

If the parts of a composition which are differently coloured are much too small they become blended together in the vision, producing the effect of some indistinct colour partaking somewhat of the hue which would be produced by the blending of the most prominent colours in the composition; while on the other hand, if the breadths are much too large, so as to require the eye to move over any considerable space or angle in passing from one to another, the beauty of the composition is in great measure lost from the inability of the eye to take in readily the different parts, and thus enable the composition to make an impression on the mind of the spectator; this arising from the want of excitement while dwelling on the dark or most neutral parts, and a want of relief while it dwells on the bright parts.

Hence, in general, the breadth may be greater for colours that do not differ very widely from the medium grey, than for colours which are more nearly allied to light or darkness, or which have some very powerful hue.

Similar considerations apply to breadths of space occupied by groups of colours of a kindred nature, which have on the whole a similar effect on the eye.

Variety of colours may be introduced into a composition and conduce very much to its beauty, provided the conditions and laws of harmony be not contravened by their introduction. Doubtless, by increasing the number of colours differing widely from each other in character, the difficulty of assorting and arranging them in such order as to satisfy the eye with their harmony is considerably increased, owing to the number of gradations and contrasts which are thus introduced or increased; but if well arranged, a composition consisting of many colours will

always far excel one containing few in beauty and continuity of charm.

For instance, if we take a pattern containing a number of equi-distant stripes of neutral grey upon black ground, and compare the effect with another pattern having equi-distant stripes of three striking colours, say, red, green, and blue, the effect of these colours will be to neutralise each other. In each case all the three colour sensations may be equally excited, each one neutralising the effect of the other, but in the first case there is no variety of colour, simply because all the three colour sensations are scattered everywhere, combining in one uniform grey, while in the second case each colour sensation is excited and relieved in turn in an appreciable degree; the beauty arising from variety being thus made distinctly apparent.

The application of the rules of harmony must of course be restricted and guided by the exigencies and proprieties of the subject of design, and the purpose to which it is to be applied. Such considerations must obviously affect our choice, and in any case in attempting to fulfil the laws of harmony the designer will find himself hampered with various influences, which tend to make full conformity with one law, much more with all the laws, almost impossible. But a moderate compliance with sound principles produces a good effect, and if the eye is pleased with some good features in the composition it will in general be very indulgent towards, and disposed to overlook, inevitable deficiencies.

But however thorough the acquaintance with the principles and laws of harmony, and with the true relations of colours to each other, useful as this acquaintance undoubtedly is, it does not, nor can it, supersede, although it must materially assist, good natural taste and sensibility to colour, or the skill and facility of harmonious arrangement which can only be acquired by careful practice.

It is frequently required in colour compositions to produce some special effect, congenial with the circumstances of the case, and for this purpose it is essential to study the mental effects which seem to attend different classes of colour, and their modes of treatment.

Colour, like music, produces different effects on the mind, and in like manner it is well known to those who have made music their study that there are three fundamental notes, viz., the first, third, and fifth of the scale, and that these notes, when sounded together, produce the common chord, which is the foundation of all harmony in musical composition.

It has been pointed out that upon the eye being fixed upon any given colour it appears to be surrounded by another colour, which is its complementary. This also applies to music; when any given note is sounded it is either accompanied or immediately succeeded by others, which are called its harmonics, this effect resulting from the vibrations or sound waves, as it results in colour from the vibrations of light, or the combination of rays.

The senses of hearing and seeing each convey to the mind sensations or impressions of pleasure or pain in the modes in which they are acted upon or excited by external objects; hearing, by such objects in their motion producing an effect upon the surrounding atmosphere, and seeing, by the action of light upon them, or, perhaps more correctly speaking, by the rays which are reflected by them through the medium of light.

It is a well-known fact that sounds when addressed to the ear in intelligible language convey to the mind a meaning, either descriptive of an idea or sentiment, or of some object which is acknowledged by the understanding. In like manner colour conveys to the mind a meaning, or produces an impression. The deepest colours impress the mind with a certain idea of solemnity and magnificence, the deepest

notes of music produce upon the mind a like impression. Clear, bright colours are equally striking, but in a different way—their effect is lively; in like manner the clear, lofty tones of music seem to raise the spirits of the listener, and if well blended together, have a most exhilarating effect.

But one remarkable difference may be observed between these two classes of colours. While the deep colours are always impressive, and from their nature must always have such an effect on the mind, clear colours lose all their excellence in the presence of brighter colours. Thus what may appear to be a full white, in a composition which is equally illuminated, is obscured at once when a bright light is introduced into a part of the composition which before had been of a less brilliant character.

The three primary colours produce different effects upon the mind, the intermediate colours partaking more or less of these characteristics, accordingly as one or other of these colours predominates or neutralises the effect of the other. As has just been said, the bright colours have a lively effect, which may be described as exciting, warm, advancing, while blue has a cool, retiring effect; but if we mix the lightest of the primaries with this cool retiring colour we produce an intermediate, viz., green, which has a refreshing, soft, pleasant effect.

To compare the effects of different colours in this respect, they should be reduced to the same intensity, made equal in brightness and strength, for the eye seems to estimate the effect in proportion to the whole brightness of colour.

Compositions of colour partake of the character of their predominant colours. When a variety of colours of like characters are brought together, the result is generally to give a more marked character to the composition, and this effect is considerably enhanced when the colours are so arranged that they mutually improve each other. Thus

a good composition of the deep primaries with black, and with some of their deep intermediaries, or of the clear secondaries with white and some of their clear intermediaries, is far more impressive or more lively than any single colour possibly could be, and the effect is more lasting, because the variety enables the eye to contemplate it with more pleasure and less liability to fatigue. So also a combination of warm colours of various hues produces a stronger and better effect of warmth than any single colour could do, and a combination of cool, retiring colours has the same effect in that direction. Compositions of a dull or neutral character are uninteresting, and if the colours are dark the effect is even gloomy and sad, unless relieved in some degree by the manner in which they are arranged, or relieved by some spark of bright, attractive colour.

On the other hand, colours differing widely in character may form compositions of the most beautiful description, presenting admirable examples of the harmony of colours, though not necessarily of a very lively or very impressive character, nor very warm, nor very cool.

The character of a composition may be affected by the number of colours, as well as by the manner in which they are put together. The fewer the colours the simpler the composition in that respect, and simplicity itself has a charm, where other causes of beauty are present.

If the colours are too numerous there is great danger lest the advantage of variety be lost in complication, confusion, and superfluity.

Sharp contrasts in colour, provided they are not harsh, tend to give strength and vigour to a composition ; easy gradations, if they do not degenerate into tameness and weakness, produce soft and gentle effects, but should the gradations be of too tame a character the result is insipidity.

Then these principles which govern harmony and contrast may be reduced to definite order, or what is termed

laws. It has already been pointed out what is meant by contrast, but this may be further qualified by dividing contrasts into three orders. First, what is termed simultaneous contrast, which simply means the intensifying of any colour by the presence of its complementary, as has already been shown; second, successive contrasts, or the tendency of the vision to create the complementary to that which is seen, and upon which the law of simultaneous contrast depends; and third, mixed contrasts, the tendency of the successive or created colour to blend with that of the object being viewed. Each of these laws of contrast is separate and distinct from the other, yet each is necessary for the existence of the other. Each one of the three may be fully and easily demonstrated by a simple experiment. If we take a bright-coloured object and look at it intently for some time the colour begins to lose its power and become dim; at the same time the eye becomes fatigued, and cannot look steadfastly at the object. If we then turn our vision to another object, the colour of which is complementary to that of the first object, the eye is at once relieved, and at the same time the colour of the second object appears bright and intense. For example, suppose we take a red piece of fabric, and look over the piece from end to end, the colour at first may appear to be an excellent bright colour, but after a short time it begins to appear dull. This is the result of the successive contrast, or the tendency of the vision to create the complementary green, and of the mixed contrast, or the tendency of the vision to blend the green thus created with the red of the fabric, and so impair the brilliancy of the red. If we then lay aside the red fabric and take up a green we see the green in an intensified degree, because the eye has created a tendency to see green by the presence of the previous red, but after looking for a time at the green piece, a reaction takes place, and the eye begins to create a tendency to see red, and so

causes the green to appear dull and approach a grey. Turn again to the red piece, and it will appear more intense than before. Thus we have all the sensations of contrast illustrated at once. Then from this it will be evident that the effect of any colour in a composition will be heightened by the presence of its complementary, but, as will presently be shown, they must be present under certain conditions only. Again, it must also be manifest that the presence of any two colours in juxtaposition, each having the same common element, will detract from the quality of both, but perhaps in a greater degree from one than the other. If we place, for example, a red and orange, a yellow and green, or a blue and purple together, we shall find in each case that one colour will detract from the other ; or we may carry this still further, if we take a black, which appears at first sight to be a dense black, and place it in close juxtaposition with blue, we shall find that the black appears to have lost some of its density and has assumed a somewhat russet hue. This arises from the blue causing a tendency in the vision to create its complementary orange. The orange thus created mixes with the black and so produces the russet hue. On the other hand, if the black in the first place has a russet hue, if it be juxtaposed with orange or red it will at once appear as a dense black, because the blue ray is created in the vision and compensates for the russet hue on the black.

It has been said that in all colour compositions the three primaries must be present to produce perfect harmony. Then the question arises, In what proportion should they be present ? There is some slight difference of opinion as to what may be considered the exact equivalence of each, but the proportions laid down by Field are generally accepted by our most practical writers as being sufficiently near for practical work.

In the scale of chromatic equivalents as laid down by

Mr. Field, the fundamental powers of the primary colours in compensating and neutralising, contrasting and harmonising their opposed secondaries are approximately as *three* yellow, *five* red, and *eight* blue; consequently the secondary *orange*, composed of three yellow and five red, is the equivalent of *blue*, the power of which is eight. They are accordingly equal powers in contrast, and compensating in mixture, and as such are properly in equal proportions for harmonising effect.

Again, *green*, being composed of blue, the power of which is eight, and yellow, the power of which is three, is equivalent in contrast and mixture as eleven, to *red*, the power of which is five, being nearly as two to one.

And finally, *purple*, composed of blue as eight, and red, the power of which is five, is equivalent in mixture and contrast as thirteen, to *yellow*, the power of which is three, or as nearly four to one. And such proportions of these opposed colours may be employed in forming agreeable and harmonious contrasts, in colouring and decorative painting, either in pairs of contrasts, or several, or all together, and also for subduing each other in mixtures.

The tertiary colour *citrine* harmonises with the secondary colour *purple*, in the proportion of nineteen citrine to thirteen purple. The tertiary colour *olive* harmonises with the secondary *orange*, in the proportion of twenty-four olive to eight orange. The tertiary colour *russet* harmonises with the secondary *green*, in the proportion of twenty-one russet to eleven green, &c.

And further, it is apparent that all compound hues of these colours will partake of their compound numbers, and contrast each according to a compound equivalence. Thus an intermediate red-purple will contrast with a like opposite green-yellow, with the power of eighteen to fourteen, and so on without limit all round the scale, and the triple compound or tertiary colours are subject to like regulations.

But there is no absolute necessity that these proportions should be exactly adhered to. Some one may be made to predominate so as to give a key tone and character to the composition.

In determining which colour shall be allowed to predominate, or give tone to the composition, due regard must be paid to the mental effect of the several colours, and to the purpose to which the composition is to be applied. It has already been pointed out that each of the three primaries produces a different mental effect. Blue conveys the impression of coolness, and appears to retire from the spectator; blue also is nearly allied to black, or darkness. Red conveys the impression of warmth, is stationary as to distance, and is the mean between light and darkness. Yellow conveys the impression of light, and advances towards the spectator. Any compound colour will partake of these characteristics just as one of the three primaries predominates, or as it is neutralised by the presence of the others. Therefore in all compositions, to whatever purpose they are to be applied, these mental effects should be duly considered, and that one selected to give tone which will be most in accordance with the object of the composition or the purpose to which it is to be applied.

Then to return to the necessity for all the three primary colours being present in any composition, either in the form of primaries, secondaries, or tertiaries. Although, as has been shown, they must of necessity be present, they need not necessarily be present in their full intensity or power, but they may be diluted or reduced to shades, tints, or hues, and in proportion as they are reduced or diluted their areas may be increased. We very rarely find either primary or secondary colours present in their full intensity, and extending over large areas, in any composition. The composition will invariably be more effective and pleasing if large areas are occupied by tertiary or neutral tints, and

enlivened by brilliant flashes of colour in the form of a full primary or secondary. Nor should powerfully contrasting colours be placed in close juxtaposition to each other without the presence of some neutral to subdue or modify their effect upon each other. If we place, for instance, red and green in close juxtaposition in any composition, although they are complementary to each other, and the presence of one is necessary to the existence of the other to produce perfect harmony, yet the effect is unpleasant. Suppose we have alternate stripes of red and green, or if we have red figures on a green ground, or *vice versa*, the eye could not rest long upon them without experiencing an unpleasant sensation, the two colours would begin to swim into each other as it were, and the longer the eye rests upon them the stronger and more unpleasant will this swimming sensation become; but if the two colours be separated by black or white, or some tertiary or neutral colour, then this swimming sensation will be entirely prevented, and yet perfect harmony will prevail. In the same manner, if blue and orange be juxtaposed the swimming sensation will result, but it may again be prevented by the introduction of neutral. If purple and yellow are placed together the effect is not quite so unpleasant, because the two colours, although complementary, are more nearly allied to light and darkness respectively. Yet even in this case the effect is much improved by the presence of tertiary or neutral colours. Therefore at all times colours which are complementary to each other should either be present in subdued form or separated from each other by the presence of some neutral colour.

In addition to this quality of modifying the effect of complementary colours, neutral colours also possess the property of modifying the effect upon each other of colours which possess the same common element. As has been shown, colours which possess the same common element,

if placed in juxtaposition, have the effect of detracting from each other, but if separated by black, by white, or by neutral colour, this mutual detraction is prevented or modified. If, for example, we place blue and green together, one colour will partly destroy the other, and the point of junction of the two will scarcely be discernible; but if we separate the two by either a black or white line, we shall find the effect materially improved. In the same manner we may deal with red and orange, or with any other two powerful or bright colours, and the result will invariably be the same.

In speaking of neutral colours, the peculiar properties of gold as a neutral may be pointed out. Although the appearance of the colour of gold is decidedly yellow, yet it is one of the most neutral colours to be met with. Not only will it harmonise with any or all colours, but it will modify the effect of any two colours, or compositions of colour, upon each other. It is for this property as much as for its peculiar richness that gilded frames are so much preferred for pictures, the richness and neutrality of the colour of the gold not only tending to improve the effect of the colouring of the picture, but at the same time effectually preventing the interference in an undue degree of any surrounding colours.

Gold is a colour which is very rarely used in textile fabrics, yet it may sometimes be used with advantage, and whenever it is used this peculiar property may be borne in mind.

Then the whole theory of colour treatment may be briefly summed up as follows:—We have three primary or simple colour sensations, and in any compositions these three sensations must be excited if we have harmony, or, in other words, the three primary colours must be present either in their pure form or in a compound form. As each colour sensation is excited it must also in turn be

relieved, thus implying that if any one is present in its most intense form the others must also be present in an equally or nearly an equally striking degree, either as to its intensity or its area. Colours which are kindred to each other will associate well; but if they partake in a large degree of the same common element they must be divided or separated from each other by some other neutral colour, or by the intervention of white or black, or light and shadow. In this latter case the light and shadow need not necessarily be present in the definite form of black and white, but it may be present in the form of an admixture of light with one colour and shadow with the other. If we take, for example, two blues or two greens, or any other colours, and place them in juxtaposition, to produce perfect harmony, or an effect pleasing to the eye, one must be reduced to a tint by the admixture of white and the other to a shade by the admixture of black, and just in the degree in which the two approximate to light and darkness respectively will their power of pleasing and producing harmony exist; because the two colours, possessing the same common element, would tend to detract from each other but for the existence of the light and shade, therefore just in the degree in which the light and shade separate them from each other will their effect be pleasing.

If we are dealing with gradations of colour precisely the same principle will apply, whether we are gradating from light to dark of the same colour or from one colour to another, therefore the more perfect the scale of gradation from one extreme to the other, the more equally balanced the extremes of the gradations are with each other, the more pleasing will be the effect. Then not only should the gradations be true and regular throughout, but the ends or extremes should be equally striking, and so balance or sustain each other. In compositions where gradations contrast and single colours occur, as will

frequently happen, there should be a correspondence or equivalence between the parts throughout, and the grouping should be so arranged that the eye is not attracted too much to one part to the detriment of the rest. This again further implies that the whole should occupy appropriate breadths, so that the eye can take in the whole of the composition at once ; or if not, such parts as do come within the range of vision must be so arranged that they do not suffer in effect by the absence of the other, or that the eye can travel from one part to another without any great effort, so that the absence of one part from the range of vision is compensated for to some extent by the facility given for viewing the whole group. By bearing carefully in mind these rules and principles, by careful observation and practice, combined with some natural aptitude, it becomes a comparatively easy task to treat variety of colour in such a manner as to conduce to beauty and to be pleasing both to the cultured and the uncultured eye.

Occasionally restrictive conditions may occur which will have to some extent the effect of marring a composition. These restrictive conditions are various, and their effect may be different under different circumstances ; but a careful consideration of their cause and effect will enable the colourist to deal with and overcome them in the best possible manner.

SUMMARY AND CONCLUSION.

As has been fully pointed out in the foregoing chapters, weaving is simply the interlacing of threads or fibres with each other for the purpose of making a fabric which might be applied to some useful purpose, and the whole art of weaving consists in the proper interlacing of these threads or fibres, so as to be best adapted to the purpose to which the fabric is to be applied, due regard being paid at the same time to the nature of the thread or fibre used in its manufacture, and where fabrics of a fancy character are required, regard being also paid to the proper arrangement and adaptation of patterns and colours. This, as has been mentioned, is generally the work of one man for a manufacturing concern, who is known as the designer. Consequently, upon the designer devolves all the duties connected with the production of new fabrics, or new patterns upon old fabrics; and upon his knowledge, not only of the principles of weaving, but also of the nature of fibres used in the production of fabrics, the theory of colour and general art principles, and a ready facility for practical application of these principles and adapting them to the fashions of his time, will his success entirely depend.

Although, strictly speaking, the art of weaving consists in the proper interlacing of these threads, and consequently an intimate knowledge of the mechanical operations or processes to be employed to obtain the result desired, closely connected with this, and in fact almost indispensable, is a knowledge of the nature and structure of the fibres employed. Such a knowledge not only materially assists the weaver in the arrangement of the patterns for

his fabric, but frequently enables him to employ materials for purposes which, but for this intimate knowledge of the nature of the material or fibre, might be entirely overlooked, or even considered unsuitable.

Treating the subject broadly, all weaving, as has been shown, is reducible to three distinct classes. Or, if we include knitted fabrics and laces, we have five classes. In the first two—plain and figured weaving—the warp threads are parallel to each other, and are crossed at right angles by the weft. The only difference between the two consists in the manner in which the threads are interwoven. In the one case the warp and weft threads are interwoven alternately ; in the other, the warp and weft may pass over any number before being interwoven. Consequently plain weaving will produce a cloth of maximum strength with a minimum of material, while figured weaving is adapted for producing weight and bulk, owing to the loose way in which the threads are interwoven permitting them to be brought closer together, and consequently allowing a greater number of threads to be put in the cloth. Again, plain weaving does not permit of the ornamentation of the fabric,—but in a very limited degree—except by means of colours, while in figure weaving the fabric may be ornamented either with or without the aid of colour.

In gauze weaving the parallelism of the warp threads is not preserved as in the other two, but they are made to cross or become partly twisted round each other in the process of weaving. The result of this is to produce an open or perforated fabric. Gauze weaving possesses in some degree some of the characteristics of both the other two. By the manner in which the warp threads are made to twist round each other in interweaving with the weft considerable strength is imparted to the cloth, and at the same time the fabric may be ornamented without the aid of colour if desired. But from the very nature of the

construction of the fabric nothing but light cloths could be produced.

Then, these, being the chief characteristics of the three primary classes of fabrics, the weaver must consider first which of these three, or which combination of two or more, will produce a fabric best suited to the purpose to which it is to be applied, and also to the nature of the material to be used for the production of the fabric. Not only must he consider the nature of the fibre of which his thread is to be composed, but also the character of the thread. He must know whether the thread possesses sufficient strength to bear the strain to which it will be subjected. If he desires to have a pattern visible on the fabric, he must consider whether the character of his thread is such that it will interfere with the pattern, as it will be certain to do if there is a great deal of loose fibre upon it. He must also consider, if the cloth is to be a plain one, whether this loose fibre will interfere with the threads in crossing each other, and if so, take means to prevent that interference as far as possible. All this may be summed up briefly by saying that all threads in which the fibres are laid parallel, or in which the amount of twist is such as to produce a clear firm thread, may be woven into fabrics in which the pattern must be distinctly visible, and all threads presenting a great deal of loose fibre must be used for goods in which the pattern is not desired to be visible. *See Appendix A.*

These observations refer chiefly to the simplest forms of weaving, such as plain and twill fabrics, or those having small, simple designs upon them, though they refer also in a more or less degree to all forms of weaving. For instance, if we are making a gauze cloth it would be an absurdity to attempt to make it with warp threads having a great deal of loose fibre on them, or with very soft twisted materials. Again, in making cloth it is a matter of

absolute necessity not only to have the material or fibre of which the thread is composed such as will be adapted to the purpose to which the fabric is to be applied, but both the material and the construction of the thread which is to form the ground of the cloth must be suitable to the purpose.

These are the primary considerations, and they are such as can only be mastered thoroughly after long practice and close attention, but these principles being once mastered, the mere mechanical operations of weaving become a comparatively easy task.

With respect to the manufacture of fancy goods much might be said, not only respecting the adaptation of the material to the purpose to which the fabric is to be applied, but also with respect to the combination of materials to produce effects, and the combination or adaptation of forms in the production of designs, as well as upon the colouring of fabrics; but no amount of writing could possibly supply that which can only be gained by practice and careful observation, and no rules could possibly be laid down which could supersede sound judgment, or supply taste, although one may be assisted and the other refined. The most valuable assistance will be found to be the knowledge gained by experience, and the most refining influence careful study of the choicest productions of nature and art.

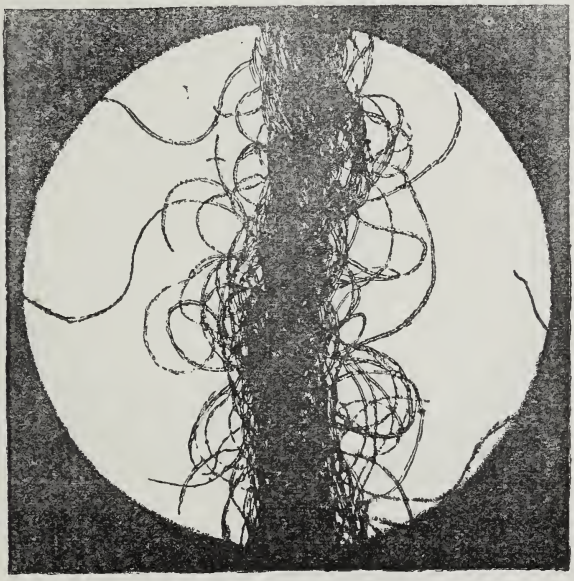
With respect to the mechanical operations of weaving, the combination, interlacing, and arrangement of coloured threads, taken separately, nothing could be more simple. If we take the three movements which have to be executed in weaving, separately they are simplicity itself, yet they are in combination beautiful, interesting, and instructive. The regularity and simplicity of the movements, the ease and rapidity of their execution, accompanied by the regular winding of the cloth on one beam, and

letting off the warp from another, and the ever ready stopping motions and protectors in the event of anything going wrong, bringing the whole at once to a dead stand, certainly present as beautiful and complete a machine as it is possible for mortal man to produce, or for the mind to conceive. Indeed, textile machinery from the first to the last process of manufacture presents as complete and remarkable an illustration of the inventive powers of the human mind, and the complete control and power of mind over matter, as is to be found in the whole universe, and certainly no art or handicraft exists more interesting to the earnest student than that which supplies one of the first requirements and most powerful elements of civilisation.

APPENDIX A.

THE STRUCTURE OF THREADS.

The general principle of the structure of threads has been pointed out already in my work "Design in Textile Fabrics," and also the uses to which the various classes of thread may be applied advantageously The accompanying



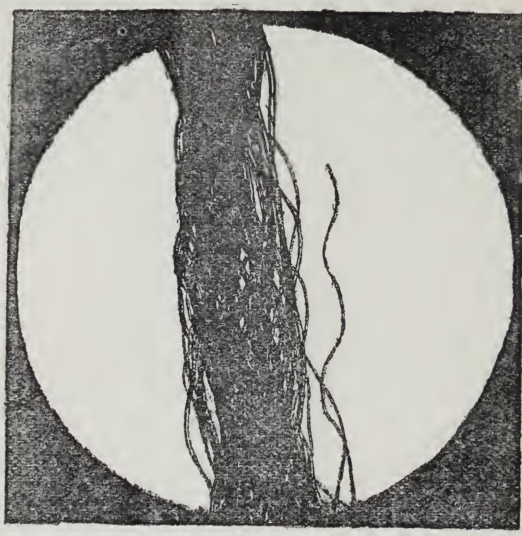
WOOLLEN YARN.

illustrations will fully demonstrate what is there pointed out. These illustrations are engraved direct from photographs of the several threads taken through the microscope and consequently their truthfulness is beyond doubt.

In the woollen thread the fibrous character is amply demonstrated and the tendency to felting in cloth made from

this yarn will be easily understood. Whereas, in the worsted yarn the perfect parallel lines of the fibres is equally well shown. The counts of the yarn from which the photographs were taken were 48 skein woollen (Yorkshire count), or equal to 22s worsted, and the worsted yarn is 24s; and for the purpose of making a fair comparison, the quality of the wool in the two yarns respectively is nearly the same.

A glance at the two yarns will at once convince one of the purposes to which they may be most readily applied.

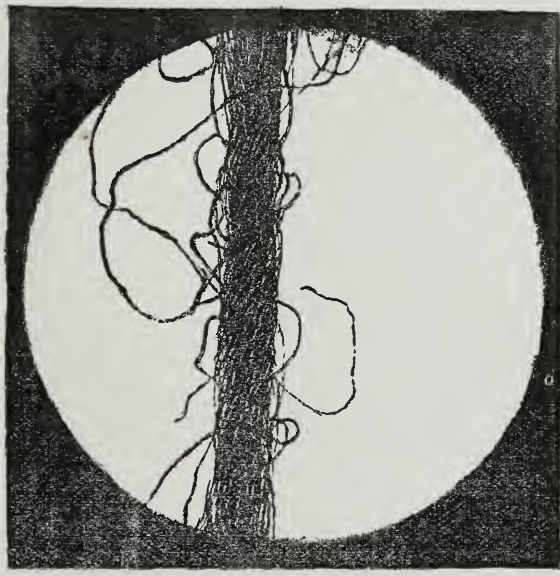


Worsted Yarn.

It will not be difficult to understand, that any pattern which may be woven in the cloth will be at once lost, at least to some extent where woollen yarns are used, and that felting will be facilitated to the utmost, whereas with worsted yarns exactly the reverse is the case; the pattern will be clear but there is nothing to assist in felting.

Turning to the cotton yarn we have one which in character comes between the woollen and worsted. The

yarn here represented is an ordinary single 80's carded yarn. This yarn is carded after the same manner as woollen, but afterwards goes through a "drawing" process, which not only tends to equalise the thickness of the yarn, but also to reduce the fibres to a greater degree of parallelism, consequently the thread presents an appearance something between the two already referred to, and possessing some of the characteristics of both. There is a certain amount of



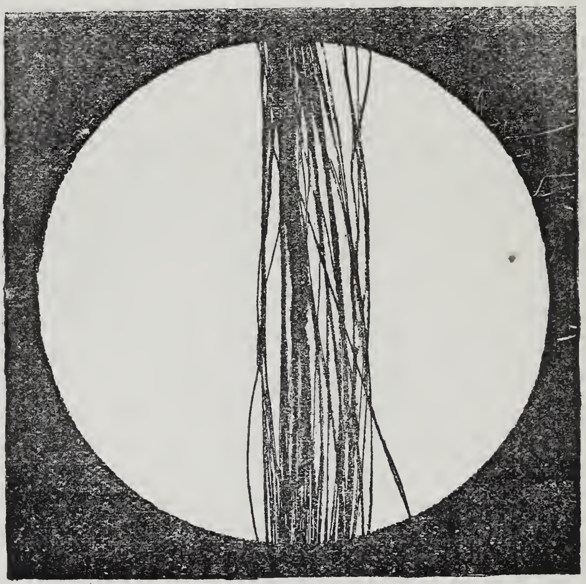
COTTON YARN.

fibre projecting from it, but not so much as from a woollen yarn, and more than from a worsted yarn.

What is known as a "combed" cotton yarn has precisely the same structure as the worsted thread, the fibres being laid strictly parallel.

The silk yarn shows the fibres strictly parallel. Of course this must always be so in all "raw" silk, that is silk drawn direct from the cocoon, as they consist of

continuous fibres, but spun silk is prepared practically on the same principle as cotton and will consequently present a little fibre, but not so much as cotton, owing to the fibre being longer. This illustration also discloses another feature



Silk Yarn.

of the silk thread, especially of wefts from which this is taken, viz., the very small amount of twist in the yarn, though of course for warps there must of necessity be a little more. The yarn from which this photograph was taken would be equal to about 96's cotton.

APPENDIX B.

THE JACQUARD MACHINE, ITS HISTORY AND USE.

Reprinted from "L'Ingenieur Universel" of 1880.

It is well known to every student that all our most useful and valuable machines have reached their highest stages of perfection by slow degrees, and that although their first introduction to the world may have been the work of one man of genius, they have undergone many alterations and improvements subsequently at the hands of others. It may also be said that many of the greatest inventions are not entirely the work of the man whose name is associated with their introduction to the world, but the result of a combination of what has been done by others in the same direction. It is always an interesting study to follow the progress of a machine from its earliest birth to its latest development, and that is more especially the case when the subject of our study occupies such an important position in one of our greatest industries as does the Jacquard machine. It would not be a difficult matter to make up a volume of interesting matter in tracing its history and development, but our object will be, with the space at our command, to sketch briefly its history and use. We need not review the personal history of Joseph Marie Jacquard, or the manner in which his machine was first brought before the world. So much has already been written upon this subject that the student will have no difficulty in learning all he may wish to know about the matter from a variety of sources. The object of the Jacquard machine is to facilitate the production of elaborate designs upon textile fabrics, and for this purpose it has

superseded what was formerly known as the draw loom. We may perhaps make this more intelligible to some of our readers if we say that the Jacquard represents and takes the place of a number of healds. Any one who knows anything of a loom will not require to be told how difficult it would be to crowd a few hundred healds into a loom, but a Jacquard may represent several hundreds of healds and not occupy an inconvenient space. For the purpose of showing as clearly as possible the use of the Jacquard machine, and at the same time to ascertain as nearly as we can how much of the merit of invention is due to the man whose name this machine bears, we will commence with an explanation of the draw loom, and from that point follow upwards.

Fig. 1 represents a draw loom harness. A is what is termed the harness; R the cumber board; C the neck; D is a pulley-box through which the cords from the neck are passed. These cords are continued, as shown at E and F, and beyond F are attached to a rod passed through a ring of the roof or ceiling of the workshop, this portion being called the tail or tail cords of the harness. To the tail cords are attached another series of cords G, which are carried down and attached to the floor by means of a rod in a similar manner to the tail. These cords are called the simples, and upon them the pattern to be woven is read; that is, another series of cords I, which are called lashes or leashes, are attached to such of the simples as will raise that portion of the harness which is required to be raised to form the pattern. They are then attached by a running noose to the cord H, which is simply a fixed cord from floor to ceiling, and parallel to the simples. So far as the harness itself is concerned the arrangement is shown very clearly, the warp threads being passed through eyes or "mails" at A, and the weights B serving to bring down such of the harness

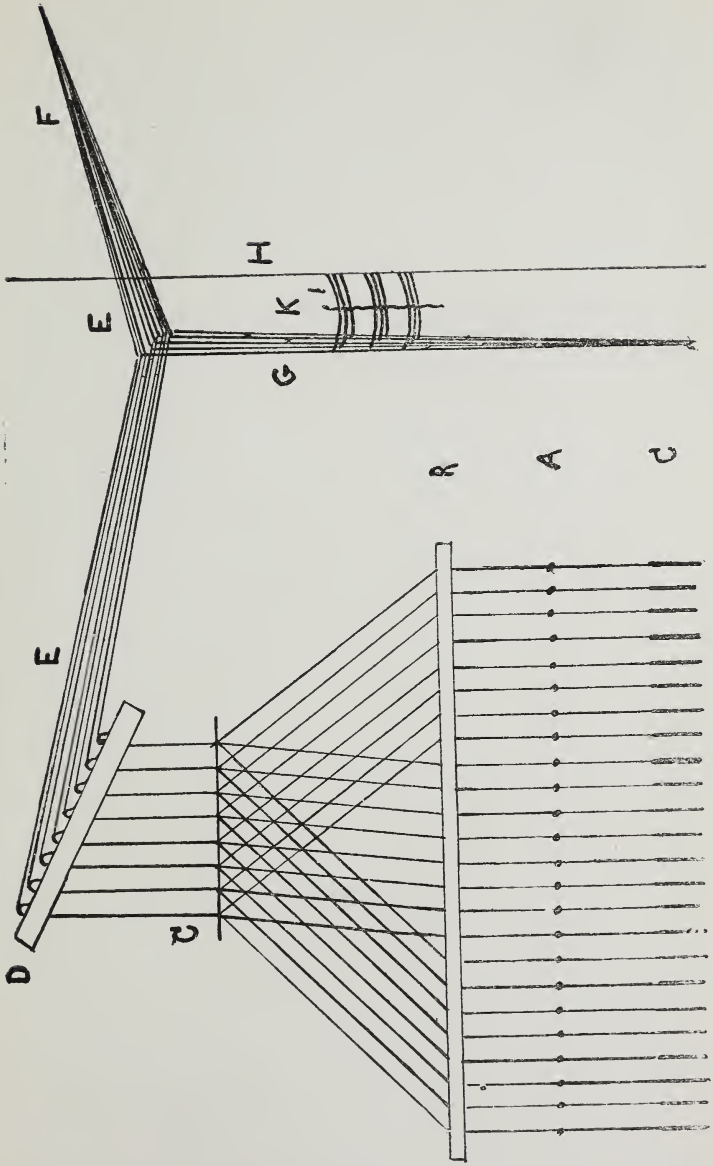


FIG. 1.

cords, and with them such of the warp threads, as have been raised. Then the duty of the draw boy is to pull the lashes I in succession as the weaver throws in the weft, and so by continually drawing the cords over and over again in the order in which they are read, the warp is separated in such manner to receive the weft as will produce the pattern desired.

This then is the principle of the draw loom in its

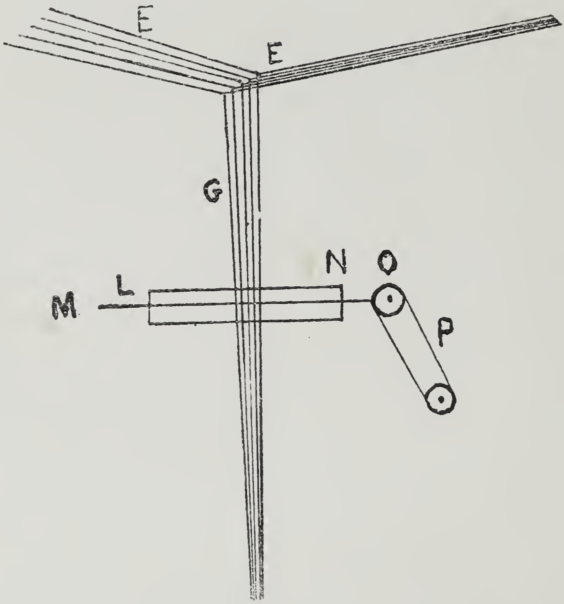


FIG 2.

simplest form. At various times machines were invented to supersede, or rather to assist the draw boy in his work, but in all of them the use of the "tail" and "simple" were preserved. They therefore consisted chiefly in mechanical means of drawing the lashes or some apparatus which should take their place. The one which most nearly concerns us at present is said to have been invented by a Frenchman, M. Bouchon, in the year 1725. In this apparatus each of the

simple cords passed through a long needle having an eye or loop formed near its middle. One end of this needle projected a little way in front of a board through which it passed. These needles were acted upon by a band of perforated paper, the perforations in which are made according to the pattern to be produced. Fig. 2 shows in a simple manner the principle of the apparatus. The parts lettered E, and G correspond to the parts having the same letters in Fig. 1. In addition will be seen a box carrying a series of needles M, through each of which one of the simples is passed; N is the needle-board with the needle projecting through it; and O is a grooved or perforated cylinder over which the band of paper P is passed. The weights on the harness will keep the simple cords in their vertical position, and consequently keep the points of the needles pressed through in front of the needle-board; then it is obvious that if the roller O be pressed against the point of the needles, wherever there is a hole in the paper opposite the point of a needle, that needle will pass through and remain stationary. But when the paper is blank the needle will be pressed back, the simple will be drawn, pulling down the tail cord, and consequently raising the harness and the warp, which is drawn through in precisely the same manner as if the leash had been pulled by the draw boy. As each leash of the draw boy serves for one pick, if the paper is perforated in rows, as shown at Fig. 3, each row would serve for one pick in precisely the same manner. In 1728 M. Falcon substituted a chain of cards and square bar for the paper of M. Bouchon; and later Vaucansen dispensed with the tail cords and simples and made the draw bar self-acting. The harness really has to serve in the place of healds, and its arrangement is as follows:—The neck cords are numbered 1, 2, 3, &c., and to No. 1 neck a harness cord is attached and carried down through the cumber board, another from Neck No. 2, and so on until a harness cord has

been attached to each neck. When this has been done we have what is termed one round or division of the harness. This is repeated as many times as will make up the desired width of the fabric; consequently, whatever pattern is formed by the first division of the harness is repeated by the subsequent divisions.

We can now begin to examine the invention of Jacquard, and to estimate its value, his machine being a combination of the principles we have shown. It has been denied that Jacquard deserves any of the merit of an invention, but that he simply deserves the credit of "an experienced workman

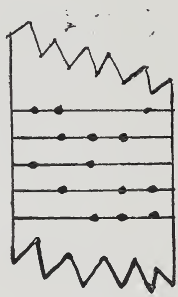


FIG. 3.

who by combining together the best parts of the machines of his predecessors in the same line, succeeded for the first time in obtaining an arrangement sufficiently practical to be generally employed." The first machine of Jacquard is said to have been completed in the year 1801, but it was some time after that when it was introduced into England. The first patent taken out for it in England was on April 11th, 1820, by F. Lambert, being "A communication from a certain foreigner living abroad," and it is described as "A new method of mounting and producing, and also of removing, preserving, and replacing the figure in weaving gold, silver, silk, worsted, cotton thread, and other laces whether made or composed of the aforesaid articles, any

or either of them, or a mixture thereof." In his specification he shows complete drawings of all the parts of his machine, cards, design, &c., and explains fully the use and mode of cutting cards, and claims that the "figure plates (cards) may be removed from the 'matrix block' (card cylinder) and another chain of figure plates substituted in its place, provided the width of the warp already in the loom be then suitable for the new fabrics, and the first set of figure plates being so removed may be preserved and kept for use at any future time," and he also claims that "by this invention an extraordinary and greater length of figure may be produced than hath ever been produced in his Majesty's kingdom." This is an ordinary Jacquard machine in its simplest form.

Before proceeding further we will describe as simply as possible the principle of this machine. It would be a difficult matter to conceive anything more simple in construction. It consists of a frame containing a series of upright hooks arranged in rows, each one of which serves the purpose of the tail cords shown in Fig. 1, and has attached to the bottom of it the neck cord from which the harness is suspended. Nearer the upper end of the hook it passes through the looped eye of a needle similar to that shown at M, Fig. 2. Then as the upright hook serves the purpose of the tail cord, the needle which crosses it serves the purpose of the needle and simple in Fig. 2, or of the lash J and simple G in Fig. 1. Fig 4 will more clearly explain its arrangement. A represents the upright hooks, and B the needles through which they pass, each of them projecting a little way through the needle board C at the front of the machine, and at their other extremity pass into the spring box D. Here each separate needle is provided with a small helical spring, which presses the needle forward and keeps the hook in its vertical position. Immediately beneath the upper extremity of the hooks a series of lifting knives are

placed, their position being such as to be under the hook when it is in the upright position. To the cords E the harness is attached; in fact they are the neck cords exactly corresponding to the neck cords in Fig. 1. The hooks are kept in position at the top by the needles through which they pass, and at the bottom by the neck cords, each of which passes through a hole in the board F, and they are prevented from turning by a grate the bars of which rest in the lower part, that portion which is turned up being carried

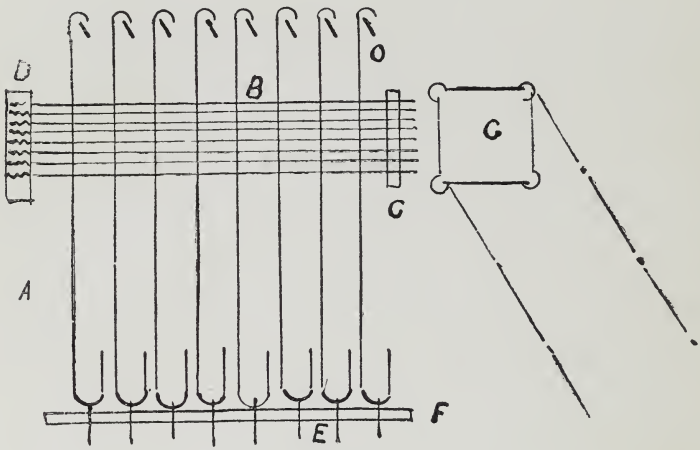


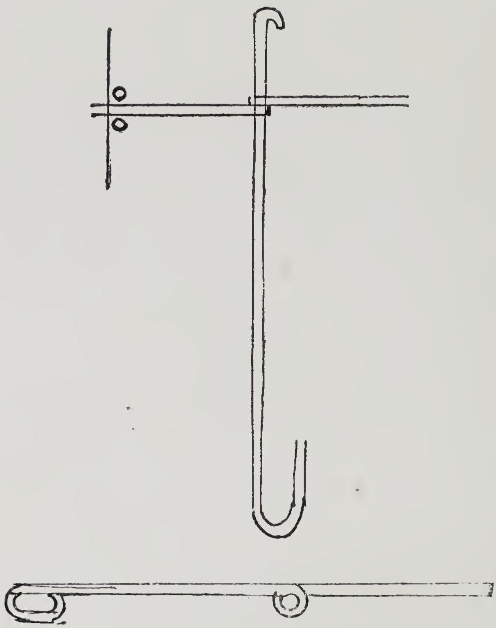
FIG. 4.

so far that the grate should never pass above it. In front of the needles is a square bar over which the cards pass, this bar being perforated with as many holes as there are needles.

If a card is placed upon this bar, wherever there is a hole in the card the needle corresponding will pass through, and the hook connected will remain stationary over the lifting knife on the bar carrying the card being pressed against the needles; but where there is no hole in the card the needle will be pressed back carrying the hook with it, and consequently taking it clear of the lifting knife. At every pick these knives are raised, lifting up such of the hooks

as have not been pressed back, and at every pick a fresh card is brought up to the points of the needles until the whole pattern is complete. This brief description represents the principle of the machine but there are details which will now require consideration. It will be obvious to the reader that some provision must be made for the lifting of the knives, for the purpose of lifting the hooks of the machine, and for bringing fresh cards in succession to the point of the needles. To perform the first of these operations the knives are firmly fixed in a block which is raised and lowered by means of a lever. In the first arrangement which was patented in England there were two of these levers employed, and the attachment came over the side of the loom. In 1821 a patent was taken out by Mr. S. Wilson, which in part refers to this matter. In previous arrangements the machine was so placed on the top of the loom that the card cylinder was towards the warp beam, but the first claim in Mr. Wilson's patent is that the cylinder, or as he terms it the "revolving bar," shall be placed at or towards the side of the loom, instead of towards the warp beam, and so enabling him to extend the machine or use two or more machines at the same time. The second claim is that by so placing the machine the lever connected with the lifting block comes over the head of the weaver, and a cord is passed behind him and attached to a treadle "by which means the weaver is able to draw the heaviest monture and figured work without the use of a draw-boy." Another improvement which forms part of Mr. Wilson's patent consists in an alteration of the form of the needles, a loop being formed at their furthest extremity from the lifting bar, which is passed through horizontal wires, and at right angles a regulating pin is passed through the loop of the needle, the extremity of the loop pressing against the helical spring which is to press it forward towards the cards as shown at Fig. 5. The cards are made to act upon the needles by

being passed over a perforated bar or cylinder, which must have such motion given to it as will bring the cards into contact with the points of the needles at the proper time, and the cards must also be brought up in regular succession. To effect this the cylinder must have a reciprocating rectilinear motion given to it, and at every motion it must also make one fourth of a revolution upon its axis. Various



PLAN OF NEEDLE.

FIG. 5.

devices have been adopted for this purpose but the one in most general use is shown at Fig. 6, where the cylinder is carried near the lower extremity of a pair of arms A, which work on a fixed centre at the top B. From the lifting block C, a rigid L shaped arm having a pulley at its extremity is carried out, and works in a curved bar D which is attached to the arms carrying the cylinder. The consequence

of this arrangement is that as the block C is raised, the pulley acts on the upper side of the curved bar, so throwing out the arm, and as the block descends it acts upon the under side, bringing the arm back and pressing the card

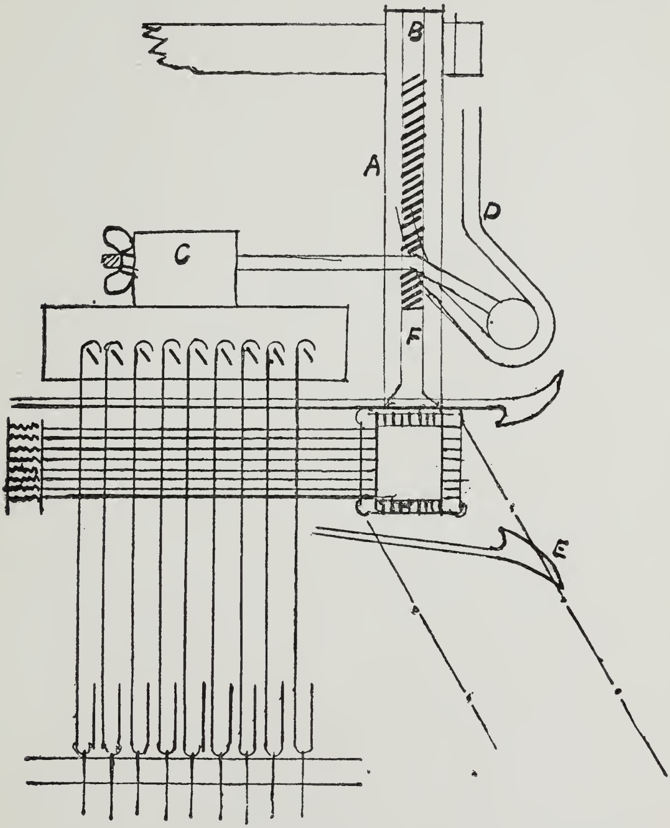


FIG. 6.

upon the point of the needles. To cause the cylinder to revolve a pair of pawls or catches E, are attached to the frame of the machine, the upper one resting upon the cylinder by its own weight, and the lower one being attached to it by a cord. As the cylinder is thrown back, the hook upon

the catch takes hold of one corner of it, and pulls it over, thus bringing the next face opposite the needles. The cylinder is prevented from revolving too far by the hammer F, which is kept pressed firmly down by a spring. The second catch is for the purpose of turning the cards in the opposite direction in the event of the weft breaking or running out.

We can now examine the improvements which have from time to time been made or attempted. It would be a study both curious and interesting, if space permitted, to follow all the attempts which have been made since this machine was invented to effect improvements in it, and it certainly seems very surprising that the machine of to-day so very nearly resembles the original one. Those improvements which are of value we shall notice and endeavour briefly to trace their history, and we shall also call attention to one or two attempts which have been made to adopt a new method. Mr. Wilson, the gentleman already mentioned in connection with the patent of 1821, made an attempt to alter the form of the machine in 1823. In this the card cylinder is placed on the top of the machine and the needles are dispensed with, and instead of using hooks for raising the warp threads he used an upright wire with a head formed upon it, immediately below this was placed two plates with holes corresponding to those in the cylinder, and through which the wires passed. The harness was attached to the wires, in the same manner as in the previous machine, by means of neck cords; but each harness cord had a knot upon it which rested upon the cumber-board when the wire was down. The cylinder with the cards acted direct upon the needles from above, the holes in the cards permitting those which were desired to be raised to remain in their position, and pressing down those which were required down so far that the button upon the wire would be below the two plates. The upper plate had a slight longitudinal

motion given to it, so as to partly close up the holes, and both plates were caused to rise together so as to catch the bottom upon the wire, and raise the harness. As the cylinder was raised the wires which had been pressed down were returned to their places by small spiral springs.

The next attempt was by Molinard in 1833, and in his specification he claims that his invention "consists in the placing of his figuring machinery under the warp and needles, and in connecting the needles themselves directly with the warp threads in such a manner that the pattern cards are using motion given to the pattern cylinder over which they pass to act upon the lower ends of the needles." This arrangement does not seem to have proved very satisfactory, for in October of the following year (1834) Molinard took out another patent for improvements. In this he abandons the needle connection with the warp and uses "a body of needles acted upon by the rise and fall of a pattern shaft or cylinder in the way described in my former specification." And he "suspends the threads of the harness by lifting or suspension threads from the aforesaid needles, by which means one of the principle advantages of my former patent is rendered applicable to a loom for weaving figured fabrics with greater economy and facility."

In 1840 a patent was taken out by Deplanque which contained several new features. From this time, improvements in the Jacquards were numerous and some of them valuable, more especially for use with power looms. One especially is of great importance, viz., that relating to the movement of the card cylinder. It will be easily understood that when the lifting block or griffe is raised, and the cylinder with the card is withdrawn from the point of the needles, those which are left down will return to their original position, and as that position is such that when the griffe is down the hooks are immediately over the knives, when the

griffe is up they must be immediately under the knives. Therefore if the knives were vertical they would strike the top of the hook, but they are inclined to such an angle, that as they descend they strike the face of the hook, and press them back.

If a Jacquard which imparts the motion to the card cylinder with the curved bar, shown in Fig. 6 be carefully examined it will be found that the cards strike the needles before the griffe has reached its lowest point ; that would seem as if it would remove all the hooks which were not intended to rise out of the way of the knives. But it also has another effect. Many of the hooks which are already on the knives are required to be pressed back so as to be left down ; then if the card is pressing upon the needles before the griffe has reached its lowest point the hooks have not been liberated, therefore there is considerable pressure upon the needles and the card, and as a consequence proportionate wear and tear. It is obvious that the most perfect motion would be for the knives to be quite clear of the hooks before the card touches the needles, and this is best done by working the card cylinder from some source independent of the machine. The first attempt at this was made by Mr. J. Bullough in 1842, when he patented "a certain arrangement or application of mechanism whereby the 'card cylinder' is made to turn entirely independent of the lifting motion for shedding the warps." Considerable additions and improvements were made to this by Messrs. Woller and Butterfield, of Bradford, in 1855. In their specification they make three claims, the first two have reference to the card cylinder, and the third to the harness. The first of their claims is "in allowing the hooks to be entirely at rest and free from the knives of the griffe, at the time when they are pressed back by the cards and cylinder ;" the second, "in the means of disengaging the cylinder or swing-frame, so that the cylinder and the cards may be worked backwards or forwards,

independently of the other parts of the machine." This

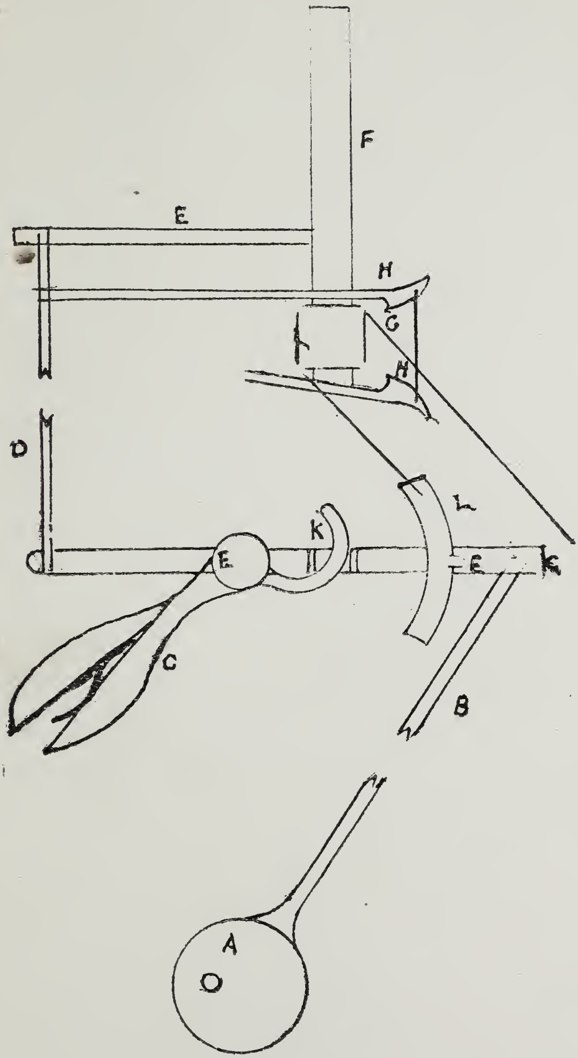


FIG. 7.

invention is of such importance that we may venture to examine it a little more fully.

In this arrangement the card cylinder is worked by an "eccentric" direct from the crank shaft of the loom after the manner shown in Fig. 7. A is the "eccentric" upon the crank shaft, the motion being communicated by means of the rod B to the lever C, and from the other arm of that lever by the rod D to the arm E. (Although we speak of C as one lever, the arm to which D is attached is quite apart from the arm C, but they are both working upon the same centre, which is a rocking shaft running across the loom behind the harness.) This arm is made fast to the swing frame F, which carries the cylinder G. It will be seen at once that as this arrangement is quite independent of the rise and fall of the griffe of the machine, the movement of the cylinder can be timed at will in relation to the movement of the griffe. The arrangements for turning the cards without moving the other parts of the machine are extremely simple. When the loom is running the cylinder is turned in the usual manner, by means of the catch H. The handle C is a split handle working upon the centre E, and provided with a spring for keeping each half in position. The movable part has at its opposite extremity an arc of a circle K upon it; and upon the fixed arm is another arc L, with a notch E. The whole of the arm is made fast upon the rocking shaft before named, and the straight arm C, to which the rod B is attached works loosely upon the rocking shafts. When the machine is working in its usual manner a "nib" upon C falls into the notch E of the large arc, so causing the rocking shaft and the loose arm to work together, or as it were to become one. When it is desired to work the rocking shaft for turning the cards without turning the loom at the same time, the handle is pressed together raising the nib by means of K, and so removing it from the notch E; the rocking shaft is therefore disengaged, and by working the handle backwards and forwards the card cylinder will be thrown out and the cards turned over

either in one direction or the other as desired, by bringing either of the catches in contact with the cylinder.

This invention has probably had a greater influence in promoting the use of the Jacquard machine with power looms than any other, because it enables the weaver to prevent broken patterns, when the weft breaks or runs out, with the greatest facility. There is no trouble turning the loom back pick by pick, until the broken one is found, but the weaver simply seizes the handle and turns the cards over to the desired one without much trouble.

The third part of this invention aimed at what has often been attempted, viz., "Keeping the harness steady and free from vibration" when working. Messrs. Woller and Butterfield endeavoured to remedy this tendency by instituting springs for the loose weights, and so enable them to run their looms at a higher rate of speed. In theory this seems very feasible, but in practice it does not seem to have answered very well, for it was very soon abandoned, and the loose weights replaced, the latter retaining their position up to the present time. This is only one of the many attempts which have been made to enable the Jacquard power loom to be run at a high rate of speed, upon some of the others we shall speak shortly. We now have the Jacquard machine in such a state of perfection that it will do its work fairly well, either on the hand loom or power loom, yet in some respects there is still room for improvement. We will now point out in what direction these improvements are desirable, and some of the attempts which have been made to effect them. With respect to the vibration of the harness we have already pointed out one of the attempts to remedy it, and we are not aware of anything better having been done. Of course in the ordinary loose weight harness some provision is made for this, by making the weights work in the partitions which prevent their swinging from side to side except for a

very limited distance. To enable the Jacquard power loom to attain a high rate of speed many attempts have been made, but the most successful has been the "double action" machine, though this system has its defects, and many practical men are of opinion that the increased speed is purchased at too high a price. The question is and always must be, whether the advantage gained is not counterbalanced by the disadvantages, or whether the increased speed is not gained at the cost of efficiency. Before we enter more fully into the double action machine it will perhaps be as well to inquire into the purpose it is intended to serve, and what advantages are to be gained by it. Putting the matter broadly there are two distinct objects

FIG: 8.

in view. One is as we have said, increased speed, and the other an improved shed, coupled with a counterpoise harness, in which the falling or sinking part of the shed would balance the rising part and effect economy in power. Then first as to the shed, that is the separation of the warp into two portions so as to permit the shuttle carrying the weft to pass between them. This may be indicated by Fig. 8, where A represents the point at which cloth is formed by the weft being beat up; the straight line B, the warp when no shed is formed; and the dotted lines B show the warp as divided into two portions to permit the passage of the whole. It will be observed that the shed is V shaped, and that the lower line is as much (or nearly so) below the straight line B as the other line is above it, or in

other words, that each one is drawn the same distance—though in opposite directions—from the straight line. It will be obvious that if we consider the line B as the natural position of the warp threads when at rest, or as we may term it the line of rest, and as the shed is opened, each half of the warp is drawn the same distance from it, the work seems to be done in the most economical manner. But in the ordinary Jacquard this cannot be done. The lower dotted line becomes the line of rest, consequently to make a full shed it must travel to the top one, or the entire depth of the shed. In the hand treadle and tappet power looms, the shed is always opened from the centre; in the Jacquard loom it is not always so, but only in those which have a double action. The principle of the double action appears to have been used by Mr. J. Cross, of Paisley, in his counterpoise harness for the draw loom. Also a few years later by Mr. B. Taylor, who took out a patent for a loom for weaving "figures or flowers on twilled or plain cloth," and which was "worked without any drawboy, the figures in the different articles being produced by means of barrels filled with wires arranged to the figures or flowers, in a similar manner to that of a barrel organ producing tunes." The harness is described as having a double neck, "and as one lash falls the other rises, and by the falling of one the weight assists the other in rising." This is simply the principle of the double action Jacquard. There are two necks and two hooks, each being acted upon by a separate griffe working alternately. In 1849 a patent was taken out by Mr. Barlow, for a Jacquard with "double counterpoised griffes and apparatus for simultaneously raising and lowering different portions of the suspending wires of such apparatus." This machine (Fig. 9) contained two sets of hooks and one set of suspending wires, it had also two sets of needles, two cylinders, and two sets of cards. The two hooks A, A are the lifting hooks; and B the suspending wire to which the neck of the harness is

attached. The suspending wire has two nuts upon it by means of which either of the hooks can raise it. Each set of hooks is acted upon by separate sets of cards and by separate griffes acting alternately. This arrangement, as may be easily understood, was too complicated, there were too many wires. Consequently the form of the hooks was altered as shown in Fig. 10, where it will be seen that the two hooks were retained, but the suspending wire dispensed with, two neck cords being used instead. In all other respects the principle of the machine remains the same.

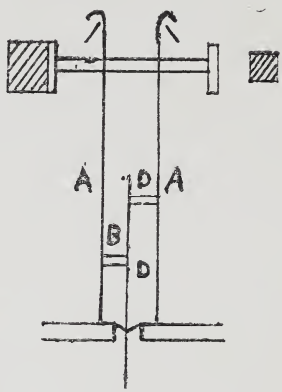


FIG. 9.

The greatest alteration in the double lift machine was made by Mr. H. Crossley, in making one needle serve two hooks, and by that means dispense with one of the card cylinders. One of the great drawbacks to this kind of machine is the amount of pressure exerted upon the cards by the needles. One of the two hooks must of necessity be upon the griffe, either rising or falling when the card strikes it to throw it off. The consequence is the card has not merely to press back the spring at the back of the needle as in the single lift machine, but as the hooks

cannot be both disengaged at the moment when the cards strike the needles considerable force must be exerted on the needle and hook. As a consequence the cards used upon this kind of machine must be very strong, and under the most favourable circumstances must wear out much sooner than those used on the ordinary single lift machine.

In 1857 a patent was taken out by Mr. J. Craven, of Bradford, for "giving independent motion to the bottom or knot board, in order that a downward motion may be given thereto at the time of giving upward motion to the lifting

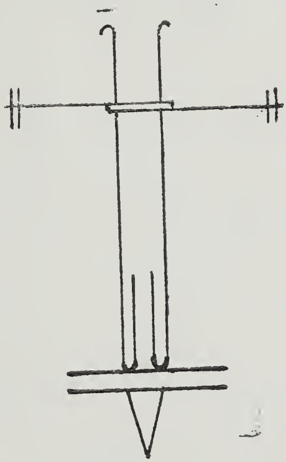


FIG. 10

blades to form sheds. In this machine "the ordinary lifting frame and the bottom or knot board are operated by separate levers and cranks, or other means, capable of being shifted or timed to vary the times of operating the parts in relation to each other as desired." In 1859, Mr. D. Sowden, of Bradford, obtained provisional protection for a means of attaining the same object. He used "two rods or slides and one lever, and one treading rod," and claimed that he "simplified working and gained some increased speed." For some reason or other Mr. Sowden did not

proceed with his patent beyond the preliminary stage. Another patent was taken out in 1876 by Mr. Ainley, of Huddersfield, and has since been largely adopted for heavy work, such as fancy woollen or worsted mantle and coating cloths. The means adopted by Mr. Ainley are extremely simple, the bottom board of the machine being carried on two arms, which are actuated by the lever which also actuate

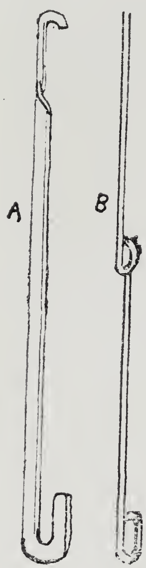


FIG. 11.

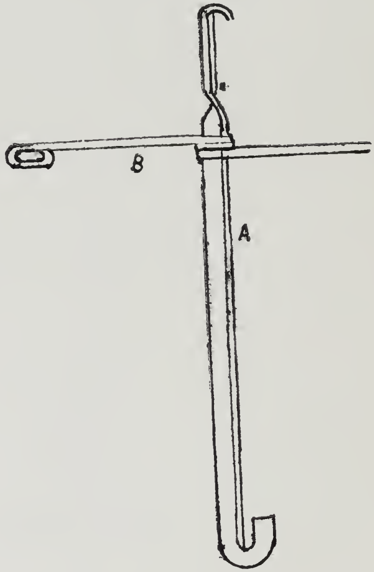


FIG. 12.

the lifting blades. Various devices have been adopted by other people with different degrees of success.

In the early part of this article we pointed out the liability of the hooks to turn, and the consequent damage resulting. Attempts have been made from time to time to prevent this as far as possible, but the grate as first introduced seems to have outlived most of them. One of the simplest and most effectual contrivances was patented in 1877 by Messrs. Dracup and Ball, of Bradford, which

consists of a simple modification in the upright hook and needle. Ordinarily the upright hook and the needle are

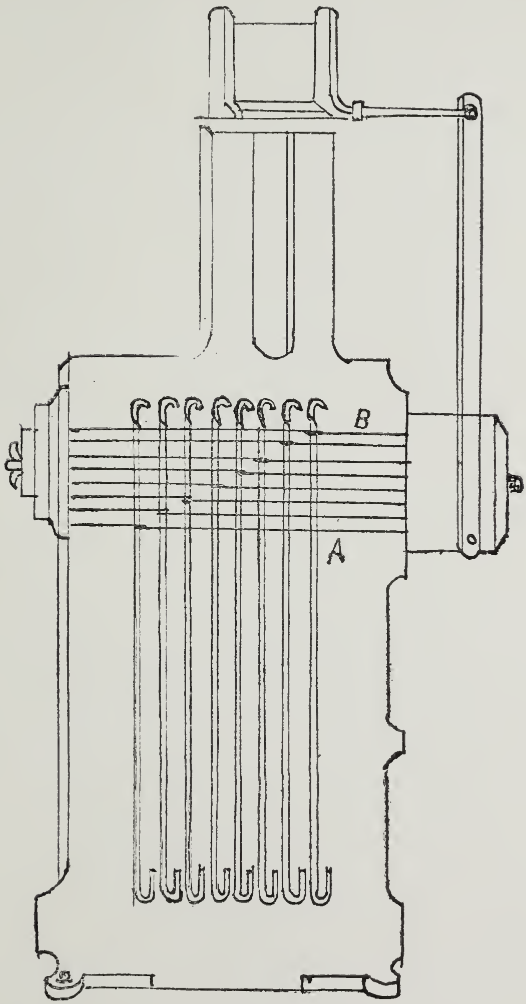


FIG. 13.

made of round wire, the eye of the latter consisting of a simple turn of the wire so as to form a complete loop.

In this arrangement the upright hook is made of flattened wire, and the eye of the needle instead of being a single loop is a double one, that is, the wire is carried twice round, so as to present greater surface to the hook. In Fig. 11 A is the upright and B the needle. In Fig. 12 they are shown together ready for putting in the machine, and Fig. 13 shows the interior of the machine with the hooks and needles placed in position. It will be at once apparent that the wire of the upright hook being flattened, and the eye of the needle elongated and presenting a double surface to the hook, that it will be a matter of impossibility for the latter to turn round, as it would if it were round, in fact it is bound to retain its proper position, and the use of the grate is entirely dispensed with. This arrangement also possesses one or two other advantages, which in practice

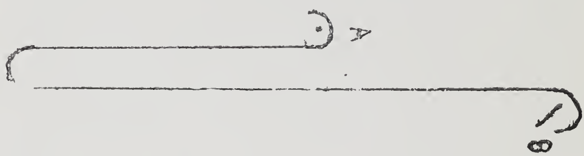


FIG. 14.

are worthy of some consideration. The hook is, near the top, twisted half round, thus presenting greater wearing surface to the griffe, and the needle, being double at the eye, presents greater wearing surface to the hook, though this may perhaps be slightly counterbalanced by a little more friction from the flat hook, and the fact that the needle has to keep it in its proper position. Again, by dispensing with the grate the bottom of the hook does not need to be turned so far up, and consequently it is a much easier matter to replace a neck cord when required. There have been more attempts to accomplish what this patent aims at. One which certainly possessed considerable merit consisted in making the hook a double one, as shown at Fig. 14. When the hook was at its lowest point the portion A rested upon a rod, in fact the hook

was so proportioned that the rod at A caught the hook before the griffe at B had left it. This and several others did their work in a fairly satisfactory manner, but could scarcely compare for simplicity and general working advantages with the flat wire hooks.

We may now turn our attention for a short time to the arrangement of Jacquard machines for special purposes. For damask weaving, for instance, some modifications became necessary, so as to enable the weaver to produce large and elaborate figures with a minimum of Jacquard power. Many figured fabrics known by the name of damask are formed by what is technically termed warp and weft twilling, or satin. For example, we may take a linen table-cloth, the ground of which consists of warp and the figure weft satin. To non-technical readers this would be more readily expressed by saying that as the pick is thrown in, there are say four-fifths of the warp raised in the figure. In the ordinary way of weaving every thread of a pattern is worked separately, consequently in some of the large patterns the extent of the Jacquard required is enormous. To reduce the machine to the lowest point a modification of the harness was early introduced, and was known by the name of the "compound" or "pressure" harness, the principle of which is briefly as follows:—We will suppose that it is desired to produce a pattern, the extent of which will occupy 2000 ends. Instead of using a machine containing 2000 hooks, we may use a machine which will contain say one-fifth of that number, 400. Then as we attach only one harness cord to each hook, it will be necessary to enable us to put in the full number of threads, to pass five threads through each mail or eye of the harness. Then to all intents and purposes these four threads become as one so far as the harness is concerned, and although we have the 2000 threads the limit of our pattern would be 400; but we now proceed to subdivide the five threads. In front of the harness we place five healds, and through each one is passed

one of the five threads, which are passed through the mail of the harness. We have then the work divided into two distinct portions, viz , figuring and twilling, the first being performed by the harness, and the twilling by the healds. It may now appear at first sight as though the figure would have a very coarse appearance from the fact that five threads must be raised or depressed at once by the harness, and so it might if the picks were arranged in fives, that is, if one card served for five picks. But each card may serve for one pick only, and thus form the pattern as clear and perfect as if each thread had a separate harness cord, because no matter how much or little of the harness may be raised to form the figure the healds have precisely the same effect in forming the pattern on the ground. The eyes or mails of the pressure healds are made considerably longer than those of ordinary healds, so as to allow of the proper formation of the shed. Of course the number of healds may vary according to the twill or satin of the ground—thus for a five thread satin five pressure healds would be used, and five threads through each mail of the harness; for an eight thread satin eight healds would be used, and eight threads through each mail of the harness, and so on. From this it will be seen that whatever number of threads are passed through the mail eye of the harness they must all be actuated at once, and the picks may be either single, or one card may serve for several, which will be kept from passing into precisely the same shed by the twilling healds. The saving effected by this arrangement must be obvious, and in hand loom working is comparatively easy of application, and although it has been very largely applied in power looms, yet the combination of healds and harness is undesirable where it can be avoided. Machines have been invented, and considerable ingenuity displayed, for the purpose of dispensing with the healds. If by actuating five threads at once and keeping each pick separate, we can produce the

pattern we desire, it must be evident that if we actuate each thread separatively, and change the figuring arrangement every five picks, the result will be the same. This principle was in use upon the draw loom before the introduction of the Jacquard, one cord being made to serve for four, five, or eight picks, according to circumstances. A patent was taken out in 1859 by Mr. J. Shields, of Perth, for the application of the principle to the Jacquard. The

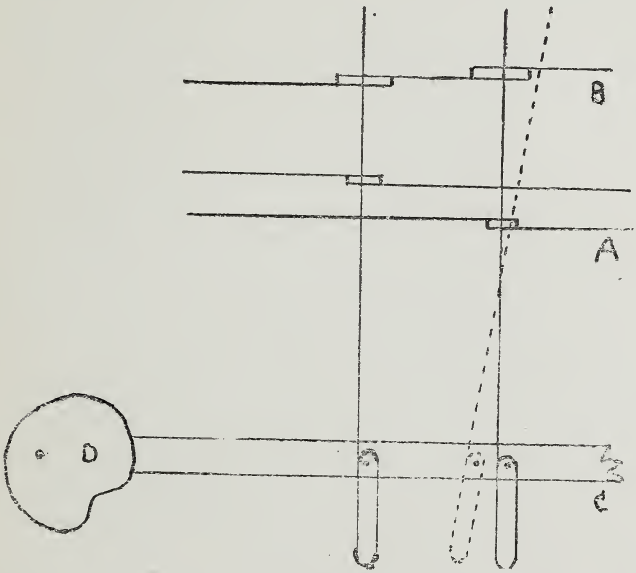


FIG. 15.

chief part of this invention consisted in "an arrangement of apparatus for working or actuating a greater number of upright wires, or needles, than has hitherto been the case by one horizontal needle, without the necessity of the latter being in parts or sectional portions. In this way the improved Jacquard accomplishes, by the aid of a harness only, all that is at present being done by a harness and a comb, or what is ordinarily known as "pressure" harness."

Described briefly, this invention consisted of two sets of horizontal needles, one being of the ordinary kind, carrying one upright hook through the eye; the other placed above, having a series of elongated eyes, and being capable of carrying any desired number of upright hooks. This arrangement is shown at Fig. 15, A being the single eyed needles; and B the elongated ones. Below the needles each upright wire has a long loop formed at the bottom, through which a rod passes. Each rod is supported on standards C, which are actuated by a cam D. There are a series of these cams, as many as are required to form the twill, each one being connected to a separate pair of standards and arranged for the twill or satin. As the figure is formed the extra needles are acted upon by the figuring cards, the ordinary shaped needles along with the cam arrangement regulating the twilling. The figuring card cylinder is made to turn at intervals of three, four, or five picks, as may be required. It will be seen that this arrangement at once dispenses with the pressure healds, and in the same manner as in pressure working, there is no necessity for cutting the twill upon the figuring cards. This saves a considerable item in the cost of card cutting.

In the following year (1860) Mr. Shields, in conjunction with Mr. A. Shields, took out a patent for an improvement in this machine, which consisted in giving the lifting knives a horizontal transverse motion to and fro in addition to the ordinary ascending and descending motion as employed for raising the Jacquard wires or needles. The horizontal motion was given by a differently formed cam or barrel, which acted upon the knives in such a manner as to cause them to take up such of the hooks as were required to form the twill, the figure being formed, as in the previous case, by the cards. Another claim was the turning up of the hooks at the bottom, the turned-up portion resting against a fixed bar and so causing it to act as a spring, similar to that shown in Fig. 14.

Another machine, which seems to be a combination of some of the best features of the two already described, was more recently patented by Mr. Barcroft, of the Bessbrook Spinning Company, County Armagh, Ireland. In this machine, which is very compact, each needle acts upon three, four, or five uprights, as desired, and one card may serve for any number of picks. The lower part of the hook is formed into a long loop, through which a twilling bar is passed, in the same manner as in Shield's first patent. The lifting knives are made movable, so as to be free to turn clear of the upright hooks when required, and are acted upon by a small barrel which is pegged according to the twill required, so that in this, as in Shield's machine, the figure is formed by the cards, and the twill by the barrel, each thread passes through a separate mail, and each card may serve for several picks.

The application of the Jacquard machine to lace weaving is a marvel of ingenuity and a most interesting study, but it scarcely comes within the range of this article to deal with.

Many attempts have been made to supersede the use of cards for the Jacquard; in some instances by the application of electricity, and in others by the use of a continuous band of paper. The inventors have been so sanguine of the success of their devices that patents have been taken out, but as yet none of them, so far as we are aware, have come into general use. Some of them have been applied to a great many machines, but their superiority over the cards not having been fully established they have gradually fallen into disuse. One of the latest of these is the "Benson Patent Jacquard," manufactured by the Benson Patent Jacquard Company Limited, of Belfast, in which a continuous band of paper is used, and although the application certainly deserves credit for ingenuity, it has not proved a success.

We have given a tolerably fair view of the Jacquard machine in the various stages through which it has passed,

and the form in which it now appears. A stranger on first seeing one of these machines at work upon a loom would probably conceive the notion that it was a strangely blended mass of wirework, cordage and mechanism, but after a brief but careful examination chaos is reduced to simplicity. After comparing the design upon the paper with the design upon the fabric, and following the connection of the cards with the warp threads, all wonder at the charming patterns which can be produced at once gives way to admiration of the beautiful simplicity of principle by which the results are attained, and the immense value of this machine to the manufacturer of fancy textile fabrics is at once recognised.

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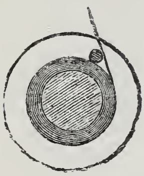
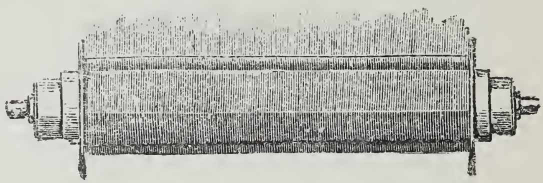


Elevation of Beam with Wax Rod in its place.



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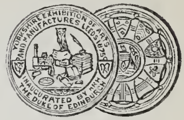
VIENNA MEDAL

1873

PRIZE MEDAL

For latest improvements in Power Looms for Weaving, London 1862.

LEEDS MEDAL



1873

GEORGE HODGSON

Machine Maker, Thornton Road,

BRADFORD,

YORKSHIRE, ENGLAND.

DIPLOMA OF HONOUR, BRADFORD, 1883.

GOLD MEDAL

PARIS 1867.

JUROR'S AWARD.

The Jury express their high appreciation of the Exhibits of Mr. G. Hodgson but since they are precluded they are sorry they cannot make the award due to the marked excellence of his machinery. The Jury however suggest that a Diploma of Honour on Vellum be presented to him. From Report of Jury, Machinery Class,

BRADFORD TECHNICAL EXHIBITION.

GOLD MEDAL

PARIS 1878.

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FOR WEAVING.

HUDDERSFIELD 1883.

CRYSTAL PALACE

1881.

GOLD MEDAL
FOR LOOMS

HUDDERSFIELD 1883.

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POWER LOOMS

Amongst which may be mentioned the following:—

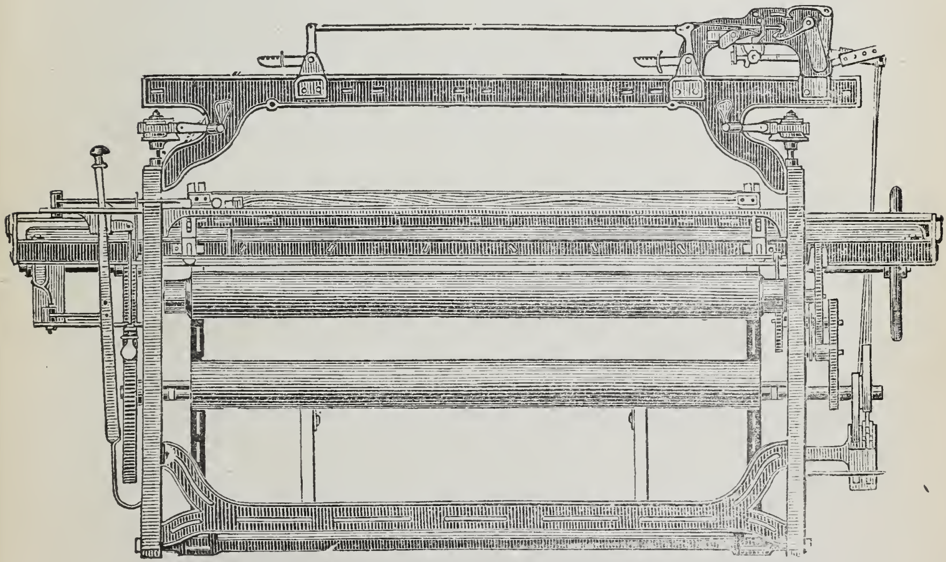
PLAIN LOOM.

This Loom (No. 1) has 32 inches reed space, and can be made to weave **Mohair, Silk, Worsted, and Cotton.** It can be fitted up to eight treads as well as figures and Jacquard. It runs very fast from 200 to 220 picks per minute. One of the same kind at the International Exhibition of 1862 ran at upwards of 450 picks per minute, but this was only done as an experiment. This Loom earned the Gold Medal in London, 1862, and in Paris, 1867.

CIRCULAR BOX LOOM.

A Loom for weaving checks, plaids, or stripes. The models are similar to the Plain Loom (No. 1) but are furnished with a patent motion for a revolving shuttle box with six shuttles, which will weave any number of even picks of colours, from two picks to any number upwards, without stopping the loom to change colour, and will remain stationary or revolve at pleasure while the loom is weaving. The shuttle box is regulated by a patent "Lock-catch," so that the box cannot overrun itself on account of locks, which, when the box is turned over are brought into play, receive the box and stop it. By this means the box can never turn too far. The aim of these patents is to accelerate the speed of the loom when weaving checks or plaids. Although the speed of the Plain Loom (No. 1) reaches to 220 picks per minute, the speed of similar Circular Box Looms has been limited to from 135 up to 140 picks. But by the application of these patented improvements a speed of from 160 to 170 picks per minute is now obtained. Besides this, owing to the former unsteadiness of the box at the instant of picking, the shuttle was frequently thrown out, causing the workpeople to incur danger of being injured, but the inventions applied to this loom prevent this. This loom is also fitted up with another patent for stopping the cards and box motion at once if the weft fails or is broken. By these means it makes the loom as easy to understand as a plain loom.

PATENT SHEDDING MOTION.



FOR WEAVING CLOTH OR HEAVY WORSTED GOODS.

By this motion any pattern can be woven from two up to twenty-four shafts, and it is worked by a plain Orlean tappet, thereby getting steadiness to the healds, the result of which is greater speed with fewer breakages in the warp. The great advantage of this motion is its acting on the warp in a similar manner to a plain loom, and we are now making them in great numbers for both the woollen and worsted trades.

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HUDDERSFIELD:

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HUTCHINSON, HOLLINGWORTH & Co.,
LIMITED,

LOO… ,

DOBC… H.

Inventors a… OOM,

Awarded b…

Also Sole … the

KN…

Awarded …

THE Loom is o… to be
done in the sam… either
in warp or weft.

The motion … o, as
in the closed sh… ttern
chain is at the s… ; thus
saving all the ti… and
pinion, and is a … long
patterns require…

Each harnes… ment
upon the yarn w… rn.

This peculia… same
opening of the w… ; thus
avoiding much … is is,
the harnesses ar…
OPEN AND AT R… MAIN

The constru… gears
are of cast steel, … ished
and hardened at… least
possible amount… that
when in use no … urce
of MISS-PICKS BY…

The pattern … can
never get out o… E TO
PUT THE WRONG…

The drop bo… , and
the chain cont… chain
WITHOUT ANY … rated
independently … e run
at great speed, a…

No combinat… rk as
readily as the m… part
of the operator.

When the c… IGHT
BOX, and cannot be made to do otherwise.

We have attached to this Loom our well-known let-off motion, viz —THE WORM AND WORM-WHEEL. This motion has now been thoroughly tested for years, and fully meets all that is claimed for it, making EVENER AND BETTER GOODS than can be obtained from Looms with the friction let-off motion. The many thousands of these motions now in use testify to their value.

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Prices and any further information may be obtained from the makers.

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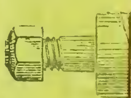

G77 As 3
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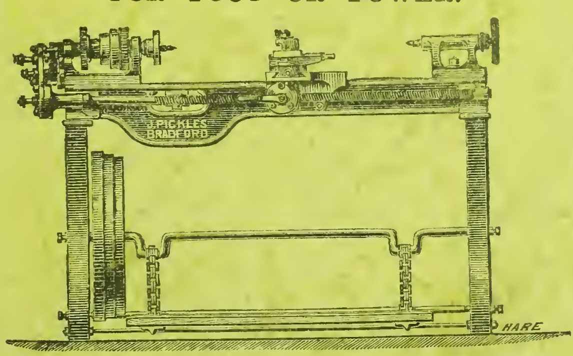
Pickers and B f first-rate

J. P. wishes e for All-Wool Cashmeres, which s acknowledged to be the best D COATING TEMPLES either guides, or the segment principle, more barrels, the best out. A sa ot satisfactory, may be returned. for any kind in large or small quantities. Illustrated Lists on application.

Small Sliding and Screw Cutting Lathes,

FOR FOOT OR POWER.

5in. Foot



Lathe.